AN EVALUATION OF THE CADASTRAL SYSTEM IN KENYA AND A STRATEGY FOR ITS MODERNIZATION

By

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DECLARATION

I hereby declare that this thesis is my original work and has not been presented in any other university for examination or award of any other degree

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This thesis has been submitted for examination with our approval as university supervisors.

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DEDICATION

I dedicate this thesis first to the Almighty God who has granted me the strength and the intellectual capacity to accomplish the thesis, for it is written in Proverbs 1:7 that the fear of the Lord is the beginning of knowledge but fools despise wisdom and discipline.

I also dedicate this thesis to my wife Alice Wayumba and our children, Elizabeth, Steven and Mary, Robert and Sandra, David and Nelly, Patrick and Benjamin; and my first grandchild Emmy Aquino.

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List of Abbreviations and Acronyms

UN	-	United Nations
FIG	-	International Federation of Surveyors
UNCHS		United Nations Centre for Human Settlement (Habitat)
USA	-	United States of America
CFD	-	Swedish Central Board of Real Estate Data
GPS	-	Global Positioning System
GDP	-	Gross Domestic Product
ICT	-	Information and Communications Technology
SWOT		Strengths, Weaknesses, Opportunities and Threats
MVVM		Multi Valued Vector Maps
GIS	-	Geographic Information Systems
MoL	-	Ministry of Lands
NACHU	-	National Co-operative Housing Union
UTM	-	Universal Traverse Mercator
PWD	-	Public Works Department
PDP	-	Part Development Plan
RTA	-	Registration of Titles Act
GoK	-	Government of Kenya
PIDS	-	Preliminary Index Diagrams
RIMS	-	Registry Index Maps
RLA	-	Registered Lands Act

IBEA Co	-	Imperial British East Africa Company
RDA	-	Registration of Documents Act
LTA	-	Land Titles Act, Cap 282 of 1908
GLA	-	Government Lands Act, Cap 280 of 1915
EMCA	-	Environmental Management and Coordination Act of 1999
NEMA		National Environmental Management Authority
L.R No.		Land Registry Number
EIA	-	Environmental Impact Assessment
LCB	-	Land Control Boards
AIA	-	Appropriation in Aid
SPRO	-	Senior Plans and Records Officer
DLASO		District Land Adjudication and Settlement Officer
RoT	-	Registration of Titles
LO	-	Land Officer
I.R. No.		Inland Registry Number
C.R No.		Coastal Registry Number
ALDEV	-	African Land Development Report of 1946
MoA	-	Ministry of Agriculture
SFT	-	Settlement Fund Trustee
IT	-	Information Technology
NLIMS		National Land Information Management System
SIDA	-	Swedish International Development Agency
CAMP	-	Computer Assisted Mapping Project
KeCIS	-	Kenya Cadastral Information System
KNSDI		Kenya National Spatial Data Infrastructure
WSSD	-	World Summit on Sustainable Development
UNECA		United National Economic Commission for Africa
JICA	-	Japanese International Co-operation Agency
LRTU	-	Land Rights Transformation Unit
UNCLOS	-	United Nations Convention on Law of the Sea
EEZ	-	Executive Economic Zone
MoU	-	Memorandum of Understanding
UNESCO	-	United Nations Education and Science Commission

INSIPE		Infrastructure for Spatial Information in Europe
ITRF	-	International Terrestrial Reference Frame
ETRF 89	-	European Reference Frame of 1989
RCMRD	-	Regional Centre for Mapping of Resources for Development
WGS 84	-	World Geodetic System of 1984
AFREF		African Reference Frame
KENFREF	-	Kenya Reference Frame
IGS	-	International Geodetic System
CORS	-	Continuous Operating Reference Stations
MoL	-	Ministry of Lands
MoA	-	Ministry of Agriculture
UN-FIG		United Nations- International Federation of Surveyors
UNCED		United Nations Conference on Environment and Development
LFA	-	Logical Framework Approach
SWOT	-	Strength, Weakness, Opportunity and Threats
ICT	-	Information and Communication Technology
UTM	-	Universal Traverse Mercator
STDM	-	Social Tenure Domain Model
MDGs	-	Millennium Development Goals
ANSI	-	American National Standards Institute
SPARC		Standards Planning and Requirements Committee
DBA	-	Database Administrator
DBMS	-	Database Management System
SACCO		Savings and Credit Cooperative Organizations
MVVM		Multi Valued Vector Maps
RDBMS	-	Relational Database Management Systems
OODBMS	-	Object - Oriented Database Management System
ORDBMS	-	Object - Relational Database Management System
DML	-	Data Manipulating Language
SQL	-	Standard Query Language
FR	-	Folio Registry
PIN	-	Personal Identification Number
KRA	-	Kenya Revenue Authority

CoL	-	Commission of Lands
ILIMS	-	Integrated Land Information Management System
CCDM	-	Core Cadastral Domain Model
KNBS	-	Kenya National Bureau of Statistics
ESRI	-	Environmental Systems Research Institute
GPS	-	Global Positioning System

ABSTRACT

The Cadastral system in Kenya was established in 1903 to support land alienation for the white settlers who had come into the country in the early part of the 20th Century. In the last hundred years, the system has remained more or less the same, where land records are kept in paper format and majority of operations are carried out on a manual basis. The lack of a modern cadastral system has contributed to problems in land administration in the country.

The Government has expressed the need to modernize the cadastral system in order to facilitate better land administration, support the development of an integrated Land Information Management System and a National Spatial Data Infrastructure. However, one persistent denominator to these efforts has been the lack of strategies for such modernization.

This study set out to contribute to the solution of this problem through the following objectives; to evaluate the current cadastral system in Kenya, to identify and analyze appropriate technologies and strategies for modernization of the cadastral system in Kenya, and to test the suitability of the identified technologies and strategies in the cadastral system.

The Methods adopted included; administration of standard questionnaires to selected stakeholders, personal interviews, field observations and review of existing literature on cadastre. Stake holder involvement in the study consisted of private and public sector Land Surveyors, Lawyers, Valuers, members of Co-operative organizations, and general users of cadastral information.

The study also carried out field measurements with selected geospatial technologies in selected study sites to assess their suitability in cadastral mapping and modelling. These technologies included; Global Positioning System, high spatial resolution satellite imagery, and Geographical Information System. Further work involved the development and testing a new cadastral model based on the Multi-Value Vector Maps approach and Smiths Normalization procedures.

The main results from the research are that; the administrative structure is bureaucratic, complex and highly centralized; the cadastral processes are equally complex, duplicative and slow; and all the tested technologies were found suitable for cadastral mapping and modelling, however, the GPS technology lacks proper guidelines for application and calibration bases.

In terms of cadastral modelling, it was found that Smiths Normalization and Functional Dependency Diagrams automatically produce fully Normalized Tables and successfully query and display of multi-parcel ownerships. The study also found out that a hyghbrid of Object-Relational database management system is better-suitable for the development of GIS-based cadastral databases than typical Relational or Object-Oriented models on their own.

The study concludes that the main problem with the cadastral system in Kenya is lack of computerization and decentralization, and therefore recommends for a complete decentralization of the administrative system and implementation of a comprehensive computerization possibly through the development of a Land Information System.

CHAPTER ONE

INTRODUCTION

1.1 General Background

Land and its resources have been the basis of wealth for most societies since the beginning of civilization. In early Mesopotamia (4000BC), Egypt (3400BC), China (700AD), and Southern India (1000AD) for instance, land was already a major source of state income through taxation [Ting, 2002]. Dowson and Sheppard [1952] also observed that during the Roman occupation of Britain (58 B.C-426 A.D), Emperor Diocletianus ordered surveys and land recordings for taxation purposes [Steudler, 2004: 8]. Similar situations were found in Northern Germany, Scandinavia, and areas occupied by the Franks, Frisians and Saxon communities where land taxation existed based on yields and supported by survey records [Larsson, 2000].

The management of such land resources, while being central to most societies, was varied in approaches and systems. In England and Wales, for example, the Saxon Kings already had feudal powers on land while in the Germanic kingdoms, private property was customarily held. Gradually, land in Germany came under powerful landlords and by the time of Emperor Charlemagne[1] (800-814AD), all land in Europe was clearly headed towards feudalism [Zweigert and Kotz, 1998].

The Norman[2] conquest of England in 1066 AD entrenched the feudal system in Europe while the Magna Carta[3] (1215 AD) was the first revolutionary step towards the establishment of

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[1] Emperor Charlemagne became King of all of Western Europe by 800AD. He ruled France, Switzerland, Belgium and the Netherlands; half of present day Germany, Italy and parts of Austria and Spain. By establishing a central Government over Western Europe, Charlemagne paved the way for modern development in Europe.

[2] William, Duke of Normandy invaded England in 1066AD and was crowned King William 1st. He is famous for compiling the Doomsday book in England in 1086AD; which contained information on land such as; ownership, acreage, land use, number of tenants and quantity and type of livestock ;but with no maps.

[3] The Magna Carter is Latin for the Great Charter. It refers to the English Charter launched in 1212AD and required the King to proclaim certain rights pertaining to Nobles and Barons. Notable among these was the *writ of habeus corpus.* It was the most significant early influence on the extensive historical processes which led to the rule of constitutional law in Europe and later, the USA.

private land ownership [Ting, 2002: 9-11]. The Industrial revolution of the 18th century in Europe accelerated the development of the individual land tenure system and introduced significant land management changes. These included the enclosure movement across Europe and the United Kingdom, which consolidated the tiny, inefficient, parcels of feudal land into larger, more productive plots.

This revolution, coupled with the move by the landed aristocracy into industry and the demand for labour in urban factories, changed the human relationship with land. The society immediately realized that land was no longer the only primary repository of wealth and identity as such other assets as industrial practices began to expand considerably. The industrialization movement also gave rise to capitalism, expanded land markets and saw the onset of major urbanisation in Europe. England takes credit as the first centre of industrialization due to its well developed and independent legal system, which provided security of tenure for private property development [Ting, 2002:18].

Ting and Williamson [1999a] and Enemark [2005] have both observed that the various stages of land tenure evolution coincided with specific human stages of development. Feudalism, for example, coincided with the growth of the city-states in Mesopotamia, Egypt, China and India, while the development of the individual tenure coincided with the onset of industrial revolution in Europe and the development of land markets. The establishment of the modern cadastre and the evolution of subdivision schemes coincided with the information revolution.

These changes are dynamic and are driven by the main global drivers such as, urbanisation, globalisation, economic reforms, environmental management and the need spatially enabled governance. Pivotal among these drivers is the tension between sustainable development and environmental conservation. On the one hand, population pressure requires that more land are converted into residential and urban land use while on the other hand, sustainable development requires effective incorporation of economic, social, political paradigms, environmental conservation and resource management principles in management.

The challenge of balancing these competing tensions in a sophisticated decision-making process requires access to accurate and relevant spatial information in a readily interactive format. In delivering this objective, information technology, spatial data infrastructures, multi-purpose cadastre and land information systems play critical roles [Williamson, 2000]. Unfortunately, most developing countries still depend on the traditional cadastre to support their land administration systems.

While these traditional cadastral systems were well suited for the simple agrarian societies, the sophisticated economies of the 21st century need the services of modern cadastre to effectively deliver the objectives of sustainable development. Stand-alone approaches that supported individual purposes are no longer sustainable. These systems are being replaced by multi-purpose cadastres where information about resources, land use planning, land value and land titles, including individual and indigenous rights, are integrated into a single geospatial database for effective utilization [Williamson, 2000: 13].

The need for modern cadastre has been a major concern of the United Nations since its inception. In 1972, the UN called together an ad-hoc group of experts to study the problems of cadastral surveying in developing countries and to consider setting up a permanent committee to constantly review the developments in this area, [UN-FIG, 1996]. Further commitments to these reforms were demonstrated in the Agenda 21 [UN-FIG, 1998] and the Habitat II Global Plan of Action [UNCHS, 1996]. At these meetings, it was recognised that efficient and effective cadastral systems are essential for economic development, environmental management and social stability in both developed and developing countries.

The Bogor–Declaration [UN-FIG, 1996] established visions for modern cadastral infrastructure and the two major paradigms that a modern cadastre is supposed to, support long term sustainable development, land management and service the escalating needs of greatly increased urban population. The Declaration thus set off a need for a clear vision in dealing with modern cadastre. These visions were actualized at the 20th FIG Congress in Melbourne, Australia in 1994 where “Cadastre 2014” was established to create a vision of how cadastres would work and look like twenty years from 1994.

The main mission of Cadastre 2014 was to develop vision statements indicating where cadastre as a concept would be in 2014. Cadastre 2014 was published in 1998 and has since been translated into 22 languages [Steudler, 2004]. The results of the study of Cadastre 2014 were basically six statements setting the international benchmarks for cadastral systems internationally. Dale and McLaughlin [1988] pioneered in this area by publishing guidelines for evaluating a cadastral system and the requirements for implementation of the multipurpose cadastre. Majority of their recommendations have been incorporated in Cadastre 2014.

Current literature on cadastre [UN-FIG, 1996; UN-FIG, 1998 and UN-FIG, 1999] emphasizes the importance of Cadastre 2014 as the international benchmark which should guide all cadastral reforms internationally. Although Steudler [2004] noted that Cadastre 2014 leans towards a technical rather than legal focus, it offers adequate solutions to the managerial and political problems of land administration and sustainable development. In its current format, Cadastre 2014 has contributed significantly towards the development of modern cadastre but is currently being modified towards Cadastre 2034 to reflect the future cadastral demands [Bennet et al., 2011].

Today, many countries in the West have moved from the traditional cadastre to modern multi-purpose cadastre through the implementation of Cadastre 2014. These countries include Sweden, Denmark, Netherlands, Germany, Canada, USA, Australia and New Zealand among others. In the majority of the countries, land registries have been modified to include coded building information and utilities, and land information systems are already web-based.

What is emerging is that while developed countries have moved on to modern cadastral systems, majority of the countries in Africa are still stuck in the old traditional systems although a few countries have embarked on the process of modernizing their cadastre in line with the internationally recognized benchmarks. These include; South Africa, Botswana, Lesotho, Ghana, Rwanda and Ethiopia, just to mention a few.

Kenya, like many African countries, still lacks a modern cadastral system; a situation which has contributed to several problems in land administration in the country. Some of the major challenges include; a large amount of manual-based land records which are increasingly becoming unmanageable and inefficient and bureaucratic and lengthy land transaction processes which impact negatively on the image of the country.

1.2 Statement of the Problem

The Bogor–Declaration [UN-FIG, 1996] emphasizes that without a modern cadastre blue print, issues such as Poverty Reduction and Economic Recovery Strategy for Wealth and Employment creation would not work. Traditional cadastral systems have enjoyed a reputation for reliability, well defined processes, and organized security of private land ownership. However recent technological changes, new human land relationships, globalization and sustainable development requirements have put a major strain on these systems.

In Kenya, the Ministry of Lands plays an important role in the achievements of the aspirations of vision 2030[4]. Land reforms have been identified as one of the foundations upon which economic, social and political pillars of Vision 2030 are anchored. Vision 2030 envisages that land reforms involve the modification or replacement of existing institutional arrangements governing possession and use of land in order to improve land administration [*wikipedia.org/wiki/Land_reform*]. Already the government of Kenya has fulfilled some of these objectives by enacting new Laws and regulations governing land. These include the National Land Commission, Land Act, and Land Registration Act among others.

These reforms are aimed at improving access to land and ensuring better utilization of the natural resources. The Ministry appreciates that the transformation envisaged under Vision 2030 must be anchored on strong policies and legal-institutional framework such as already entrenched in Chapter Five of the Kenya Constitution, 2010.

[4] Vision 2030 is an economic blue-print by which Kenya intends to attain a newly industrializing, middle-income economy by the year 2030. It is based on three main pillars: Economic, Social and Political.

The achievement of these noble goals requires an integrated approach to land development and an efficient land market. To this extent, Agenda 21 [UN-FIG, 1998] already recognised that the integrated approach to land development is one of the most important denominators to delivering the objectives of sustainable development in the 21st century. If Kenya has to achieve the objectives of sustainable development and Vision 2030, the government needs to embark immediately on a programme of modernization of the cadastral system as this is the spatial framework which supports the implementation of such development agenda.

The Ministry of Lands, in its Strategic Plan (2008-2012) and performance contract (2010/2011) already identified that to ensure effective and efficient service delivery to the clients; processes, procedures and practices of handling land information need to be re-designed. It further noted that such re-design should include, Business Process Re-Engineering, and targeted four bench-marking activities towards achieving these objectives. These four bench-mark activities included a review and documentation of current processes, procedures and practices; redesigning procedures and processes of land administration; making recommendations for quick-win projects; and implementation of a National Land Information System [MoL, 2011: 17].

Bogaerts and Zevenbergen [2002] however cautioned that restructuring cadastral systems is a slow and difficult process which requires sensitivity to a country's historical and institutional heritage. It is here that the rights and responsibilities of different sectors of the society do clash because land restructuring creates changes that affect rights and responsibilities, and therefore hold possibilities for disagreement. The Bogor-Declaration [UN-FIG, 1996], also recommended that in order to improve a cadastral system, it is necessary first to identify its bottlenecks, weaknesses and inefficiencies.

Once these weaknesses have been fully documented and evaluated, it is then possible to re-engineer the system for efficient delivery of cadastral services to the users. Such re-engineering often require changes to legislation, modification of institutional and administrative systems, and the use of geospatial technologies.

Therefore from the foregoing discussions, it is evident that the re-design of any cadastral system, requires a comprehensive evaluation in order to establish its strengths and weaknesses in order to propose the re-design strategies. At the moment, there has been no comprehensive study of the cadastral system in Kenya to support fundamental re-thinking and re-design in line with modern cadastral standards. Additionally, there has not been adequate study to identify and analyze appropriate technologies and strategies which may support meaningful re-design of the system.

The discussion presented above indicates a lack of sufficient knowledge on the current status of the cadastral system in Kenya, and no information on the appropriate technologies and strategies that can drive the current cadastre into a modern system. Pursuant to these issues, the following research questions need answers:

- What is the current status of the cadastral system in Kenya?
- What are the appropriate Technologies and Strategies that can help propel Kenya’s Cadastre into a future modern cadastre?
- What is the performance of these Technologies in real practical cadastral situations in Kenya?

Arising from these observations and the above statement of the problem, the objectives of the study can be stated as follows.

1.3 Research Objectives

The specific objectives of this study are:

- To evaluate the current cadastral system in Kenya
- To identify and analyze the appropriate techniques and strategies for the future needs of Kenya’s Cadastre
- To test the suitability of the identified techniques and strategies in the Cadastral System.

1.4 Justification and Relevance

Land is critical to the economic, social and cultural development of Kenya. It is crucial to the attainment of economic growth, poverty reduction and gender equity. Its importance has been clearly recognized by various Government initiatives including the National Poverty Reduction Strategy Programme (1999-2015) and the Economic Recovery Strategy for Wealth and Employment Creation Programme (2003-2007). Some important issues relating to land have for a long time not been adequately addressed. These include; access and distribution, duplicity in the maintenance of the land records, and registration of land rights in the informal settlements.

In terms of access to land, culture and traditions continue to support male inheritance of family land while there is lack of review of gender sensitive family laws. There is conflict between constitutional and international protocols on gender equality vis-à-vis customary practices that discriminate against women in relation to land ownership and inheritance. Apart from women, several groups in Kenya have not had adequate access to land. These include minority communities, pastoral communities, the disabled, the poor and the marginalized groups. Sessional Paper No.3 of 2009 on National Land Policy however taken care of this discrimination and now both men and women have equal rights on land rights.

In terms of land use planning, some of the major problems inadequately addressed in the land administration system; unsustainable production from agricultural land, inadequate land use planning, poor environmental management, and poor ecosystem protection. The major challenge facing the Government is the facilitation and integration of multi-sectoral approach to land use in both the urban and rural environments. This is partly due to the uncoordinated approach to land use planning and partly due to the duplication of planning services in the land administration sector. Additionally, the challenges are complicated by the duplicity in the management land information in the country.

Institutions managing land in Kenya are varied and may. These include the Ministry of Lands, the Local Authorities, Ministry of Environment and Natural Resources, Kenya Wildlife

Service, various parastatal organizations and United Nations Organizations. UNCHS [2001] observed that with the expanding user requirements, the system has become cumbersome and fraught with delays in searches. Additionally, it is an inefficient and time-consuming systems with complicated planning, zoning and overall management of land.

The informal settlements, on the other hand, have also emerged as a new tenure system in both the rural and urban areas in Kenya. This is mainly because; the production of low-cost housing in the urban areas has been hampered by the high building standards required by local authorities, scarcity of land appropriately zoned for such development, and the development of housing which is biased towards middle and upper income groups [NACHU, 1990][5].

To address these problems, the government recently adopted Sessional Paper No.3 on National Land Policy to guide the country towards a sustainable and equitable use of land. The policy intends to address the critical issues of land administration, access to land, land use planning, restitution of historical injustices, environmental degradation, conflicts, unplanned proliferation of urban informal settlements, outdated legal framework, institutional framework and information management. It recognizes the need for security of tenure for all Kenyans and promotion of multi-sectoral approach to land use planning and enabling environment for a sustained economic growth.

Secure land tenure has been identified as a critical factor in increasing productive investments in the urban and rural areas, and encouraging sound and sustainable management of land and natural resources. It also enables the poor to contribute to, and benefit from, processes of economic growth and transformation. According to the Bogor Declaration [UN-FIG, 1996], to achieve sustainable resource management and the development of future world population explosion, secure land tenure systems and effective cadastral structures must be available. Larsson [2000] and Osterberg [2001] also recognized that accurate and reliable land information systems are fundamental to the economic development of any nation.

[5] NACHU is the National Cooperative Housing Union Ltd. An NGO under the Ministry of Co-operatives concerned with the up-grading of the informal settlements in Kenya.

The Bathurst Declaration [UN-FIG, 1999] observed that developing countries are experiencing a massive migration of population into the urban areas, where poor people are increasingly concentrated in slums and informal settlements. It is estimated that, in these countries, 88% of the population growth during the next 25 years will be in urban areas [UNCHS, 1996]. Kenya is not an exception to these population growth scenarios. Already, the city of Nairobi alone accounts for about 10% of the National population and it is estimated that 60% of this population lives in the informal settlements. Conflicts and competition for land are bound to increase unless a proper land management strategy is put in place.

The Habitat Agenda, on the other hand, emphasizes that access to land and legal security of tenure are strategic prerequisites for the provision of adequate shelter and for the development of sustainable human settlements in the urban areas. Agenda 21 [UN-FIG, 1998] observes that plans, policies and actions for sustainable development depend on access to appropriate spatial information. These observations justify the re-engineering of the traditional cadastral systems into modern cadastre.

The success of a digital cadastre is highly dependent on the data structure, analysis and conceptual data modelling. Within the realm of a Geographic Information System (GIS), data included in the data model, have the longest life span and is the most expensive. Lemmen et al. [2003] observed that cadastral modelling is a basic tool facilitating appropriate systems development and re-engineering. Modelling also forms the basis for meaningful communication between parts of the cadastral system. Tuladhar [2002] also justified the use of cadastral models as an instrument for assessing user requirements and understanding the existing cadastral system.

Cadastral data modelling is therefore instrumental in the following areas; the establishment of a digital cadastre, filling in legislative gaps, document emerging relationships between humankind and land, and improving the database integrity by maintaining logical, temporal and topological consistency. Cadastre 2014 in its statement number three clearly states that the future cadastre will depend on modelling rather than maps and there will be no draftsmen in the new cadastral systems. The establishment of a multi-purpose cadastral database therefore offers an invaluable contribution towards the modernization of the Kenya cadastre.

1.5 Scope and Limitations of the Thesis

Specifically, the parameters chosen for evaluation include technical and legal aspects. Apart from these performance indicators, other parameters that are considered include; security, simplicity, timeliness, accessibility, and sustainability.

Cadastre 2014 Model has listed six statements which present where cadastral systems should be by the year 2014. These statements have a strong impact on the development and performance of cadastral systems and were therefore considered in the evaluation process. The main parameters evaluated from the Cadastre 2014 Model included; the legal situation of the cadastre including rights, restrictions and responsibilities, spatial data integration, level of cadastral modelling, private and public partnership, and cost recovery.

In terms of the identification of the appropriate technologies and strategies, the study confined itself to the assessment of selected modern equipment such as; GPS, High Spatial Resolution Remote Sensing Satellite Imagery Cadastral Database model, and Geospatial Information Systems. Thurston et al. [2003] have identified that in modern times, these are the most crucial technologies that define the future of the cadastre and understanding how they perform in terms of cadastral mapping has a great bearing on assessing the level of modernization of the cadastre itself.

1.6 Significance of the Study

The study addresses the problem of the status of the cadastral system in Kenya and how it can be re-designed for future relevance. The output from the study will provide a comprehensive documentation of the system for the first time in almost a hundred years. Such a document is essential in the re-designing the system to provide better services to the users.

In assessing the modern geospatial technologies, the study will provide a basis for; assessing the accuracy of GPS as a cadastral mapping tool, the suitability of satellite imagery in cadastral mapping in terms of resolution, and the GIS Database system as a tool for data integration. The findings of this study are therefore key in the re-designing and operation of the future Kenya's cadastre.

Although the study uses Cadastre 2014 as the international Benchmark, it is observed that the international community has proceeded and designed a new cadastre expected in 20 years from cadastre 2014; Cadastre 2034. The findings of his study will provide a basis for re-organizing the Kenya cadastre towards the future cadastre models.

1.7 Definition of Key Terms

Modernization: In the context of this thesis, modernization means the process of re-engineering a traditional cadastral system into multipurpose cadastre in line with the requirements of Cadastre 2014 and Future Cadastre such as the proposed Cadastre 2034.

In re-engineering cadastral systems, Dale and McLaughlin [1988] have emphasized that four particular areas need a close scrutiny and proceeded to summarize the four areas as; adjudication and the demarcation of rights in land, determination and demarcation of boundaries, conduct of surveys, and parcel description and recording.

Land: Land is defined as the basis of all wealth. It is the ultimate resource, for without land, life on earth cannot be sustained. Land is both a physical commodity and an abstract concept in that the rights to own or use land are as much a part of the land as the objects rooted in its soil [UN-ECE, 1996:10]. The Bathurst Declaration [UN-FIG., 1999] further notes that land as a scarce and fragile resource is an object of environmental protection.

Land is equally an asset for economic and social development. As an object with secure land rights, it has the capacity to underwrite and accelerate economic development through the treatment of land rights as a marketable commodity. Its capacity for wealth generation, for attracting and locating investment, and for opening opportunities for development of the financial sector, is critical to socio-economic development.

A Cadastre: A cadastre is a parcel based, up-to-date land information system containing a record of interests in land (e.g. rights, restrictions and responsibilities). It includes a geometric description of land parcels linked to other records describing the nature of the interests, the ownership or control of those interests, and often the value of the parcel and its improvements. It may be established for fiscal purposes (e.g. valuation and equitable taxation), legal purposes (conveyancing), to assist in the management of land and land use (e.g. for planning and other administrative purposes), and enables sustainable development and environmental protection [UN-FIG., 1995].

A Cadastral Survey: A cadastral survey is the term used to describe the gathering and recording of data about land parcels. Cadastral surveys are concerned with geometrical data, especially the size, shape, and location of land parcel. The results of a cadastral survey are isolated plans of a parcel or a subdivision [Steudler, 2004:24].

Land Registration: Land Registration is defined as the process of recording legally recognized interests (e.g. ownership and use) in land [Zevenbergen, 2002: 27]. The term registration refers to an active process, whereby the result should be called a register and an organization doing this is referred to as a Registry. Land Registration refers to a predominantly legal registration, where one can see who owns some real property. It contains the relevant legal documents regarding real property.

Land Administration: Land Administration is the process of determining, recording and disseminating information about the tenure, value and use of land when implementing land management policies. It is considered to include land registration, cadastral surveying and mapping, fiscal, legal and multi-purpose cadastre and land information system [UN-ECE, 1996].

1.7 Organization of the Thesis

The thesis is divided into six chapters as follows:

Chapter One introduces the subject, presents the problem statement, research objectives, scope, significance of the study, definition of terms and the organization structure.

Chapter two addresses the subject of Evaluation of the structure of the cadastral system in Kenya and its processes. Under the structure, issues addressed include, the organizational structure, tenure systems, boundaries, and registration systems. The processes addressed include; allocation of Government land and Trust Lands, Land Adjudication programmes, land registration and subdivision of both urban and rural lands in Kenya.

Chapter three presents a review on the search for a modern cadastral system. This chapter basically dwells on the identification of the appropriate technologies and strategies for modernizing the cadastral system in Kenya. It reviews the achievements and challenges of the current system and looks at the international benchmarks upon which modernization should be anchored.

Chapter Four deals with research design, methodology of data collection, categories of data collected, and methods of analysis of the same.

Chapter Five presents data findings and Analysis. Here, the results of the study from various sources data collected are presented and analyzed.

Chapter six is the final chapter of this thesis which presents the conclusion of the study. Included in here are the conclusions, recommendations of modernization strategies, areas of further research and significant contributions of the study to the body of knowledge.

CHAPTER TWO

THE CADASTRAL SYSTEM IN KENYA

2.1 The Structure of the System

The origins of the cadastral survey system in Kenya date back to 1903 when a land survey section was established in the then Public Works Department (PWD[6]) with the main objective to support alienation of land for the European settlement in the White Highlands. In 1906, the section was elevated to the status of a fully fledged, autonomous department (the Survey Department) under the Director of Surveys [SoK[7], 1954; Caukwell, 1977]. Today, roughly a century later, the Department has grown into a major organization with branches across the entire country.

At the political level, the Minister of Lands is responsible for the administration of the cadastral system in Kenya through the Permanent Secretary and the heads of departments of Survey, Lands, Physical Planning, Land Adjudication and Settlement. Recently, the department of Land Reform Unit, Administration and Planning were created. The various departments depend on each other for the supply of information needed for the day-to-day administration of land. For example, the Commissioner of Lands initiates the process of land alienation and allocation while the Director of Physical Planning prepares the Part Development Plans (PDPs) based on the spatial information provided by the Director of Survey. Figure 2.1 shows the current structure of the Ministry of Lands in Kenya.

2.2 Cadastral Surveying and Mapping System

The conduct of cadastral surveys in Kenya is controlled by the Survey Act, Cap 299 of the Laws of Kenya with the Director of Surveys as the administrator of the Act on behalf of the Government. Since 1986, most of the cadastral surveys have been privatised and are exclusively conducted by Licensed Land Surveyors. Today, the Government's primary role is

[6] The PWD was the Public Works Department, the precursor to the present day Ministry of Works and Housing.
[7] SOK refers to the department of Surveys in the Ministry of Lands. The department is responsible for all cadastral operations in Kenya.

that maintaining supervisory role and ensuring quality control in the execution of the surveys through the enforcement of a Code of Ethics and the Survey Act through the Land Surveyors Board.

As a result of surveys which have been carried out in the country since 1903, large amount of cadastral data have been generated over the last 100 years. These include survey plans, field notes, computations, registry index maps, aerial photographs, topo-cadastral maps, the 1: 50,000 adjudication boundary maps, deed plans and title deeds. Majority of the records are kept by the Director of Surveys except for copies of title deeds which are kept by the Commissioner of Lands. According to Njuki [2001], about four million hectares of land have been surveyed and registered under the precise cadastral survey system since 1903.

2.3 The Cadastral Boundary Systems in Kenya

Kenya operates three types of boundary systems: fixed boundary, general boundary and the fixed general boundary. These boundary definitions are either based on the English general boundary system as practised in Britain under the Land Transfer Act of 1875 [Larsson, 2000: 42] or the fixed boundary system based on the Torrens[8] system from Australia [Larsson, 2000; Steudler, 2004]. The fixed-general boundary has been adopted to achieve fixation of the general boundaries in areas where the land markets have appreciated.

2.3.1 The Fixed Boundary

The fixed boundary system is one which has been accurately surveyed so that any lost corner monument can be re-established precisely from mathematical measurements. Monumentation for fixed boundary surveys consist of coordinated beacons at the turning points of rectilinear boundaries. Natural features such as rivers, roads, and ocean line, may also be adopted as curvilinear boundaries. All fixed cadastral surveys from all over the country are examined and authenticated by the Director of Surveys in Nairobi. Under the fixed boundary system, all the parcels have their plans indicating area, bearings and distances between the boundary beacons.

[8] Sir Robert Torrens, a graduate of Trinity College Dublin, introduced a land title registration system in Southern Australia in 1858. This system was introduced in Kenya in 1919 and was supported by the Registration of Titles Act.

Where surveys are carried out under the Registration of Titles Act (RTA)[9] for the establishment of fixed boundaries, the surveyor prepares deed plans with respect to each plot, which, after signing and sealing by the Director of Surveys, are forwarded to the Commissioner of Lands to support registration [Mwenda, 2001]. Areas which were surveyed under the fixed boundary method: new grant allocations, urban leases, Trust Lands that have been set-apart for public use, Forest Reserves, National Parks and National Game Reserves, and company and cooperative farms where shareholders opt for a fixed survey.

Fixed boundaries have the advantage of easier relocation and re-establishment, especially where physical boundary marks are missing. For a long time, the fixation of these boundaries was optional. However, with the enactment of Land Registration Act No. 3 of 2012, it is now mandatory that all survey boundaries presented for registration must be georeferenced. This has the effect that from the date of the enactment of the Act, the general boundary system is extinguished. Although no reliable figures are currently available, it has been estimated that the total number of properties under the fixed boundary system are approximately 300,000; and the total area so is 3.4 million hectares [Mwenda, 2001].

2.3.2 The General Boundary

The term general boundary means that the exact location of the boundary is undetermined but assumed to be represented by a visible physical feature such as hedges, walls, rivers or streams, coastlines, or any physical feature that may be found suitable for the definition of the position of the boundary. The concept of general boundaries was introduced in Kenya in 1959 by the Native Lands Registration Ordinance and the registry map was intended to be used as the index map [GoK, 1966: 70].

The use of general boundaries was adopted to demarcate newly adjudicated land parcels in the former Native Reserves. At the time of implementation of the general boundary system (in

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[9] The Registration of Titles Act, Cap 281 was enacted in Kenya in 1919 to register the newly surveyed White Settler Community land in Kenya. Most of these settlers required secured title rights which they could use as collateral in England to acquire loans for land development. The RTA is still used in many parts of Kenya up to the present day.

1954) the needed to speed up land registration in the Native Reserves as the indigenous inhabitants had not received any title to land since 1903 when the cadastral system was established.

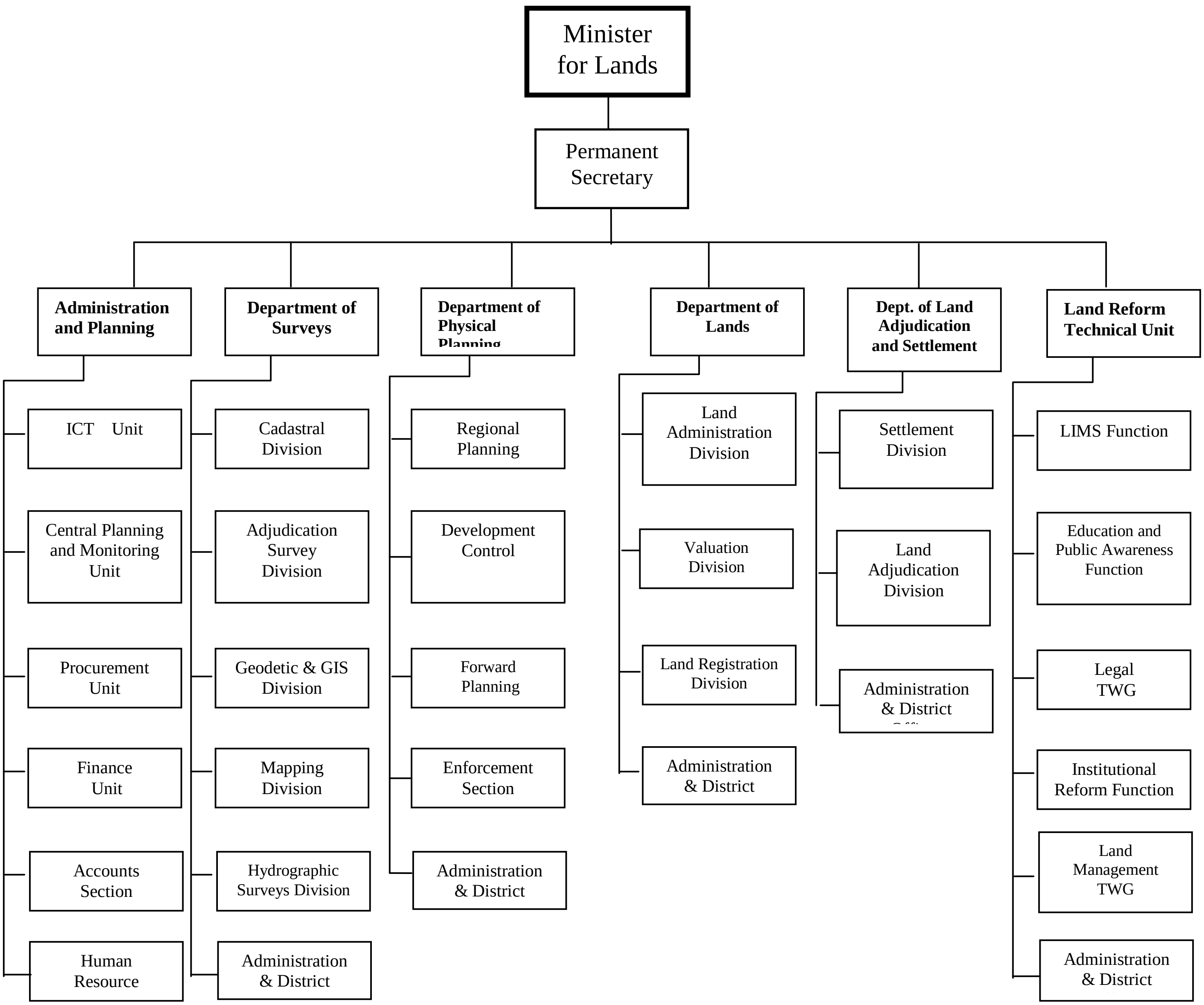

Fig 2.1 Current Structure of the Ministry of Lands (Source: Department of Surveys, 2009)

In creating the general boundaries, landowners were then asked to mark the boundaries of the plots by planting hedges as guided by the demarcation officers. Once the hedges had grown sufficiently, aerial photographs were taken at the scale of 1:12,500 and further enlarged to scales of 1:5000 or1:2,500 to facilitate the generation of representative Preliminary Index Diagrams (PIDs)[10].

The aerial photographs initially generated were meant to be subsequently ortho-rectified in order to eliminate geometric distortions and produce more reliable representations of the land parcels [Adams, 1969]. This was to be accomplished through the re-fly[11] of the areas under adjudication. However, after coverage of a few areas, the refly system was abandoned in 1967, largely due to shortage of funds and high demand for titles. The Lawrance Mission[12] also recommended for the abandonment of the re-fly programme (in the consolidation areas) in order for the survey staff to concentrate in the new, accelerated, adjudication programmes [GoK, 1966: 61].

The general boundary surveys are lodged and processed at the District Survey Offices. Once the surveys have been checked and found acceptable, the Registry Index Maps (RIMs) are amended by the District Surveyor and the amended plans are forwarded to the District Land Registrar for preparation of titles. Several generic forms of the RIMs exist in Kenya, depending on the nature and accuracy of survey. These are the Interim Registry Index Maps, the Demarcation Maps, Registry Index Maps Provisional, Preliminary Index Diagrams and Registry Index Maps-Range Provisional [Mwenda, 2001].

Areas covered by the general boundary surveys are: (i) areas where land Adjudication and consolidation surveys have taken place; (ii) group ranches where the shareholders opt for a general boundary survey; (iii) company and Cooperative Farms where the shareholders opt for a general boundary; and (iv) settlement schemes acquired from the former white settlers. Available statistics in the Ministry of Lands show that general boundaries currently cover approximately 11 million hectares of land (comprising of 1.5million parcels and 338 group ranches) [Myles et al., 2009].

[10] Preliminary Index Diagrams (PIDs) are the tracings of land parcels images from enlarged un-rectified aerial photographs which served as interim cadastral maps in support of rapid land titling [Nyadimo, 2006].
[11] The reflies were the fully rectified aerial photos taken after the hedges had grown substantially to be air visible.
[12] Lawrance Mission was a government sponsored Mission in 1965-1966 to investigate ways of how land adjudication programme could be speeded up

2.3.3 The Fixed General Boundary

Sections 21 and 22 of the Registered Land Act (RLA) give the Chief Land Registrar the authority to cause a general boundary to be fixed by surveying to the level of a fixed survey. The areas where fixed general boundaries apply are: (i) company and cooperative farms, where the shareholders have opted for a fixed boundary survey; (ii) group ranches where the shareholders have opted for a fixation survey; and (iii) areas where boundaries were previously surveyed under general boundaries but the clients later opted for a fixed survey to improve on the relocation and re-establishment of boundary beacons.

The procedures involved in the fixation of general boundaries generally consist of notifying the District Land Registrar of the intention to have the boundary fixed. The Land Registrar informs the abutting neighbours of the intention to have the boundary fixed and if any objection is raised, the matter has to be referred to the Land Control Board, otherwise the survey is executed and the Land Registrar certifies (on the survey plan) that the boundary has been fixed. Such plans are submitted to the Director of Surveys for checking and authentication in line with the requirements of the Survey Act. The fixation of general boundaries assists in mathematical re-establishment of the boundary beacons, minimization of potential boundary disputes and raises the market value of the land.

2.4 The Land Tenure Systems in Kenya

Kenya operates five main land tenure systems: the Public Tenure, Private Tenure, Customary Tenure, the Informal Tenure and the Ten-Mile Coastal Strip. While the customary tenure dominates most of the rural lands in Kenya, the private and public tenure systems control land in the urban areas. The informal tenure is dominant in the urban areas as well as in several large scale farms in the country in the form of squatters**.** The Ten Mile Coastal Strip is found only in the coastal area of the country and has the longest history of all the tenure systems in Kenya.

2.4.1 The Public Land Tenure

According to the Sessional Paper No.3 of 2009 [GoK, 2009: 16] public land comprises all that land that is not private land or community land, or any other land declared to be public land by an Act of Parliament. Currently, any surveyed public land is registrable under the Permanent Secretary for the Ministry for Finance.

All public land were originally, administered under the Crown Lands Ordinance of 1902 and the Government Lands Act Cap 280 of 1915. These lands were vested in the President of the Republic of Kenya who over the years had powers to allocate or make grants of any estate, interest, or rights, in or over unalienated government land. However, with the promulgation of the new Constitution this power is now vested in the National Land Commission.

To secure tenure to public land, the Government has carried out the following actions; repealed the Government Land Act and established a Land Registration Act which has taken over all the registration aspects of the GLA, established a Land Act under the National Land Commission which will identify and keep an inventory of all public land. Additionally, the National Land Commission will establish the office of the Keeper/ Recorder of Public Lands who will prepare and maintain a register of all public lands and the related statistics. The National Land Commission will also establish a Land Titles Tribunal to determine the bona fide owners of land that was previously public or trust land.

2.4.2 The Private Land Tenure

There are two major forms of private land ownership in Kenya: freehold and leasehold. Most of the land parcels held under freehold have been created through land adjudication and consolidation or allocation of government land for private development. At present, freehold land are found in areas where land has been converted from trust land to individual tenure mainly through the process of land adjudication and consolidation. In Nairobi, pockets of freehold land are found in areas which were originally owned by the Imperial British East African Company (the IBEACo)[13]

[13] The IBEACo was a Bombay based Imperial East Africa Company (in India) that was granted a charter by Queen Victoria in 1885 to operate, open, and administer the East African Territory from the coast inland on behalf

Leaseholds are interests in land granted for a specific period of time. In Kenya, leases may be granted for 30, 33, 50, 99, 999 and 9999 years. The 99 years and 33 years leases may be granted by the Commissioner of Lands for urban plots. The 30 and 50 year leases are granted by the Local Authorities. The 999 year leases were granted to the white settlers in 1915 under the Government Lands Act. At the moment, 20% of land in Kenya is estimated to be under private tenure system [Njuguna and Baya, 2001]. The 9999 year leases are found in parts of the Coast Province, the former white highlands and Nairobi area. These are special leases that were granted alongside the 999 years leases. The Constitution of Kenya 2010 fixes the maximum time for leases in Kenya at 99 years. Consequently, all leases with a time-frame above 99 years will be reviewed accordingly.

2.4.3 The Customary Land Tenure

Customary land tenure is the system of land holding and land use which derives from the operations of the traditions and customs of the people affected. Customary law derives from the accepted practices of the people and the principles underlying such practices [Ezigbalike and Benwell, 2007]. The most important feature of customary land tenure is the dominance of community land-right institutions which control how land is used and disposed.

In Kenya, this tenure system refers to unsurveyed land owned by different communities under customary laws. Being a diverse country in terms of its ethnic composition, Kenya has multiple customary tenure systems, which vary mainly due to different climatic conditions and agricultural and cultural practices. The tenure system is currently governed by the Trust Land Act Cap 288 of 1939.

At present, land under customary tenure occupies approximately 70% of the total area of the country and most of these lands are gradually being converted to private tenure through the process of land adjudication. Customary tenure systems are generally mixed with other tenure

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of the Queen; and Sir William Mackinnon was given the responsibility of managing the company. The IBEACo failed due to poor infrastructure and lack of structured public administration in the region and handed over its operations to the East African Protectorate in 1895.

systems in the Group Ranches[14], the Trust Lands and the Ten-Mile Coastal Strip. With the promulgation of the Constitution of Kenya 2010, all land transactions in the Trust Lands will be governed by the new Community Land Act 2013.

2.4.4 The Informal Land Tenure

Informal land tenure refers to a situation where the actual occupation and use of land is without legal basis. Under this arrangement, groups of people occupy public or private land without the permission of the owner. In Kenya, such situations normally occur in the urban areas where rapid urbanization outstrips the capacity of the urban management to deliver sufficient and affordable housing.

The production of low-cost housing affordable to low-income migrants has not kept pace with the spread of the informal settlements due to; high building standards required by the local authorities, scarcity of land appropriately zoned for such development, and development of housing biased towards the middle-class and upper income groups. Available statistics [NACHU[15], 1990] indicate that currently, 60% of Nairobi residents live in the informal settlements

For a long time, the Law in Kenya did not recognize the existence of this tenure. However, since the promulgation of the new constitution, informal tenure has been recognized in law and the government has put in place mechanisms for the provision of secure tenure for the informal settlements through the Kenya Informal Settlements Improvement Programme (KISIP) [MoH, 2010]

2.4.5 The Ten-Mile Coastal Strip

The Ten-Mile Coastal Strip in Kenya is a piece of land approximately ten nautical miles wide from the high water mark of the Indian Ocean. It covers an area of 5,480.44 square km and is

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[14] Group Ranches are as special form of communal tenure established under the Land [Group Representatives] Act of 1968 and granted to a group with common customary rights over a defined piece of land.
[15] NACHU is the National Cooperative Housing Union Ltd. An NGO in the Ministry of Housing concerned with the upgrading of the informal settlements in Kenya.

approximately 536 km long, stretching from the mouth of River Umba at the Kenya-Tanzania border to Kipini at the mouth of River Tana, and the Lamu Archipelago.

The land tenure system in the Ten-Mile Coastal Strip has been dictated by the changing political circumstances in the area. Under the East African Regulations of 1897, people living in the Ten-Mile Coastal Strip were issued with certificates of ownership for a term of 21 years in the form of short-term leases. In 1902, land in the Ten-Mile Coastal strip was considered as government land, and therefore available for alienation under the Crown Lands Ordinance. However, without some specific legal process, it was difficult for the government to separate land available for alienation and private land claimed by the Arabs [Okoth-Ogendo, 1976].

A provision for land claims within the Ten-Mile Coastal strip was therefore made possible in 1908 through the Land Titles Ordinance; which was specifically enacted to adjudicate the land rights in the area in order to separate private land from crown land. A land court, consisting of a recorder of titles, a surveyor and administrative officers was set up to listen to and determine the claims. The duties of the Recorder of Titles included boundary surveys and the preparation of maps to be attached to the certificate of ownership. The Surveyor and the administrative officers only received the claims. The process of adjudication was therefore solely left to the Recorder of Titles [Okoth-Ogendo, 1976].

During the adjudication process, most of the land parcels claimed by the landlords as private property were actually occupied by the indigenous people. The government is therefore currently faced with a complicated situation where majority of the indigenous people in the Ten-Mile Coastal strip do not have secure titles to the land while the absentee landlords, who hold the titles, are not residing on the parcels but are charging fees to the occupants on what the indigenous communities consider as their ancestral land.

2.4.6 A Critique of the Land Tenure System in Kenya

Some of the problems that have been observed in the current land tenure system can be summarized as follows; the high to medium potential zones are dominated by small farm holdings which are not economically viable. In some cases, insecure land tenure systems have led to low investment in land improvement and productivity. Many small-holder areas are suffering continuous fragmentation of land holdings into uneconomic sizes, and farms are getting smaller in the high rainfall areas.

2.5 Land Registration Systems in Kenya

Land registration system in Kenya is conducted in two main systems: the deeds registration and title registration systems. The deeds registration system was the earliest form of registration introduced by the Colonial government towards the end of the 19th Century. The system is governed by Part XII of the Crown Lands Ordinance of 1902 (repealed in 1910 by the Land Titles Act Ordinance and in 1915 by the Government Lands Act), the Registration of Documents Act (RDA), Cap 285 of 1901, the Land Titles Act, Cap 282 of 1908, and the Government Lands Act, Cap 280 of 1915.

Title registration is governed by the Registration of Titles Act (RTA), Cap 281 of 1919, and the Registered Land Act (RLA) Cap 300 of 1963. More recently, in 1987, the Sectional Prosperities Act No.21 was enacted to provide ways and means of registering sectional properties including flats. The latest addition to land registration in Kenya is the new Land Registration Act No 3 which was enacted on 2nd May 2012. The Act is supposed to revise, consolidate and rationalize the registration of titles to land. It is also supposed to give effect to the principles and objects of the devolved government in land registration and other related issues.

The commencement of this Act repeals the existing registration Acts such as; the Indian Transfer of Properties Act of 1882, the Government Lands Act Cap 280 of 1915, the Registration of Titles Act Cap 281 of 1919, the Land Titles Act Cap 282 of 1908, and the Registered Land Act, Cap 300 of 1963. In addition to the Land Registration Act, other Acts which affect land registration in Kenya are the National Land Commission Act No. 5 of 2012, and the Land Act No. 6 of 2012.

2.5.1 Registration under RDA

The RDA was the first registration Act in Kenya. It was a simple deeds registration system introduced in 1901 to register land transactions of the Crown Lands Ordinance and earlier land allocations[16] at the Coast. The Act required that registration of transactions be effected within six months of execution. A copy of the registered documents was retained in the registry and an index of names registered was kept. The registration processes under the Act were not supported by any survey plans hence it was difficult to locate the registered property on the ground. Under the RDA, the proprietor had to trace the root of the title to the satisfaction of any intending purchaser.

Initially, registries for the RDA transactions were opened up at Mombasa, Nairobi, Malindi, and Naivasha. The Malindi and Naivasha registries were closed in 1915 and their records were amalgamated with Mombasa and Nairobi registries respectively. Two records were established under the RDA system; the “A” register which was compulsory and the “B” register which was voluntary. The compulsory register recorded all the transactions in land and immovable property while the voluntary register was used as a public record of any deeds or other instruments which might be accidentally lost. The Principal Register of Documents administers this Act.

The RDA is basically an optional registration system where titles are registered as deeds without any supporting documents such as, survey plans, deed plans. Apart from land documents, the system also registers such documents as marriage certificates, deed poll for change of name, architectural plans, aerial photographs and building plans. The government is currently in the process of converting all registration systems into the new Land Registration Act No. 3 of 2012 which has repealed all registration Acts except the RDA.

2.5.2 Registration under LTA

Under the 1887 concessions, the 1894 and 1897 land regulations, and the 1895 land treaties, it was generally agreed that all existing land rights of the Sultan of Zanzibar within the ten mile

[16] Available literature [Caukwell, 1977] indicates that prior to the declaration of the Protectorate status over Kenya; several land transactions had taken place between the IBEACo and the Sultan of Zanzibar.

coastal strip, be recognised and respected by the new colonial administration [Caukwell, 1977]. The Crown Lands Ordinance did not include these lands as Crown Land. The Land Titles Ordinance was therefore enacted to facilitate adjudication of land claims within the ten nautical mile coastal strip. Through this process of adjudication, it was possible to identify land which was legally occupied and the unoccupied land that could be alienated as Crown land.

The Act provided for the establishment of a land Registration Court presided over by a Recorder of Titles. A surveyor was attached to the court to define the boundaries of the adjudicated land claims. Upon adjudication by the Recorders Court, the successful claimants were issued with certificates of title. These certificates, according to the nature of the title adjudicated, were of three kinds; certificate of ownership, giving a freehold title, a certificate of mortgage, and a certificate of interest, covering fixed assets on the land, e.g. bore holes, houses or plants.

2.5.3 Registration under GLA

By 1915, it had become clear to the Colonial government that the Crown Lands Ordinance, with its six pages of simple provisions, was inadequate to maintain a firm control on land matters as the protectorate developed [Caukwell, 1977]. The Government Lands Act repealed the Crown Lands Ordinance of 1902 and authorised the Commissioner of Lands to issue 99 year leases for urban plots and 999 year and 9999 year leases for the agricultural land. Under the Act, registration of grants and transactions is compulsory; and unregistered documents or deeds have no validity in Law.

The registries at Malindi and Naivasha, set up under RDA, were closed and the registers in these stations were transferred to Mombasa and Nairobi. The Act is basically a deeds registration system supported by authenticated survey plans and approved deed plans. Under the Act, three registers were opened: one in Mombasa and two in Nairobi. One of the registers in Nairobi was for land within Nairobi and its environs while the other register was for land in the European settlements in the White Highlands.

Titles registered under the GLA are kept in the registry as volumes and folios (pages) of the register, with one folio being devoted to each parcel of land. Any transaction over the land parcels are supported by indentures. Registration system under the GLA is either considered as Conveyance or Assignment, depending on whether the property is a freehold or leasehold. Conveyances are freehold titles while the Assignments are leaseholds under the GLA. Under this system of registration, the owner keeps the original registration documents and only copies are kept at the Land Registry; which are then used to prepare an indemnity for the government against loss, damage or alterations.

2.5.4 Registration under RTA

With the promulgation of the GLA in 1915, the white Settlers started to insist on title registration rather than deeds registration [Okoth-Ogendo, 1991:44]. Thus the introduction of the RTA was seen as a culmination for the demand of title registration since1896. The RTA was therefore enacted principally to provide for a title registration system as opposed to the deeds registration which was practiced under the RDA, LTA and the GLA.

The Act was modelled upon the Torrens system of Australia and partly on the English Common Law as spelt out in the Land Registry Act of 1862 [Larsson, 2000]. According to the Lawrance Mission report [GoK, 1966: 65], the Act was not well drafted and by 1927, three separate committees had recommended for its repeal and replacement but the proposal disappeared due to the desire to have a uniform registration system for the three East African countries.

The Act took over all the previously registered deeds under GLA, or those subject to the certificates of mortgages, or any other interests issued by the Recorder of Titles under LTA and the RDA. It also applied to all leaseholds that had been converted from the terms of 99 years since 1902 (or even those of 999 years) to freeholds, and to any titles converted on a voluntary basis from GLA or LTA to RTA Titles. According to Okoth-Ogendo [1991:44], with the enactment of the RTA, the disinheritance of the African communities in Kenya, within the framework of colonial Law, was complete.

2.5.5 Registration under RLA

Prior to the enactment of RLA, the government realized that some form of legal framework had to be developed to support the land consolidation program already in progress in Nyeri Districts since 1945[17] [Sorrenson, 1967: 135]. The Native Land Tenure rules of 1956 were passed under the Native Lands Trust Ordinance of 1939 to give the programme some legal backing [GoK, 1966:37]. In 1959, the Working Party on African Land Tenure Reforms recommended the enactment of the Native Lands Registration Ordinance, although its applications had already been adopted in 1957.

In 1960, the Native Lands Registration Ordinance was changed to Land Registration (Special Areas) Ordinance. The registration component of this Act was repealed by the Registered Land Act, Cap 300, of 1963. Parts I and II were not altered and became the Land Adjudication Act of 1964 [Onalo, 1986: 48]. In 1968, after the Lawrance Mission Report, the name was changed to Land Consolidation Act Cap 283 of 1968.

The Registered Land Act (RLA) was enacted to provide a complete code of land registration system in Kenya. It was the objective of the Government that this statute would eventually replace all the other Acts dealing with land registration in Kenya. At the time of enactment, the Act superseded the registration provisions of the Native Lands Registration Ordinance of 1959 and the Land Registration (Special Areas) Ordinance of 1960. The Act applies in areas where land have been surveyed under the general boundaries (as in adjudicated areas), areas where land have been fixed under Section 22 of the Act; or areas which are being converted from the RTA to RLA under the Sectional Properties Act.

2.5.6 Land Registration Act No.3 of 2012

This is an Act of Parliament to revise, consolidate and rationalize the registration of title to land, to give effect to the principles and objects devolved government in land registration, and connected purposes. This Act has repealed all the previous land registration Acts in Kenya

[17] Chief MuhoyaKagumba of North Tetu began land consolidation in his location in 1945 and Chief Elliud Mugo also started the process in Iria-Ini location in Nyeri at the same time

except the Registration of Documents act. Section 7 (d) stipulates that parcel files containing the instruments which support subsisting entries in the land register and any filed plans and documents must be georeferenced.

2.5.7 A Critique of the Registration Systems

The current land registration system has too many statutes dealing with the registration of land. No attempt has been made to harmonize these statutes to ease the process of registration of land rights and facilitate speedy access to land registration information. There is therefore a need to harmonize the registration statutes to enhance the efficiency, transparency and accountability in the process of land registration.

The Government recently enacted Land Registration Act No. 3 of 2012 to harmonize the statutes dealing with the registration of land rights. However, there are still no operation rules and the repealed registration Acts are still in operation. This state of affairs is not conducive to good business practices and may affect the operations of the land market in Kenya.

2.6 The Cadastral Processes in Kenya

2.6.1 General Introduction

The main cadastral processes discussed in this section cover; the preparation of Part Development Plans, allocation of government land and trust lands, subdivision of urban and rural lands, and land adjudication and registration of title. These account for majority of the precise cadastral processes in Kenya.

2.6.2 Physical Development Plans

The first step in all the cadastral processes is the preparation of development plans; which can be broadly classified as structural plans and Part Development Plans (PDP). The main objective of physical planning is to achieve economy, convenience and beauty, and ensure that the right development takes place [MoL, 1991: 19]. These objectives require regulations, restrictions and consultations which are vital for the protection of the interest of the general public. In Kenya, all land use planning processes are controlled by the Physical Planning Act, Cap 286 of 1996 and the Environmental Management and Coordination Act (EMCA) of 1999.

2.6. 3 The Physical Planning Act

This is an Act of Parliament to provide for the preparation and implementation of physical development plans and for connected purposes. The Act repealed the Land Planning Act Cap 303 and the Town Planning Act Cap 134. The Physical Planning Act of 1996 regulates the profession of physical planning in Kenya through the Physical Planners Registration Board. The Act also controls the establishment and composition of the Physical Planning Liaison Committee in accordance with section 8 of the Act.

One notable fact is that the planning stages presented in Table 2.1 are a bureaucratic, lengthy and repetitive; a situation which not conform with the demands modern economies. In the Sessional Paper No. 3 of 2009, the Government proposes to carry out a re-organization in the Physical planning sector as a means of rationalizing the planning stages and reduce bureaucracy. The reorganization is expected to cover; a review and harmonization of the Physical Planning Act (Cap. 286) and the Local Government Act (Cap 265) and other relevant legislations in order to improve planning services.

2.6.4 Allocation of New Grants

The process of allocation of new grants is initiated by the Commissioner of Lands or the President of the Republic of Kenya[18], who under the Government Lands Act, Cap 280, of 1915, alienated several land parcels to various organizations and individuals through direct land allocation. The recipients of the grants thereafter write letters of acceptance to the Commissioner and the allocation process is initiated.

After all the processes have been accomplished, the requisite fees are paid before title deeds are issued to the allotees. The fees required include Land Rents, Land Rates, Stamp Duty, Survey fees, Stand premium, and any other fees that may be imposed by the Government from

[18] This authority has however been repealed since the promulgation of the new Constitution on 27th August 2010.

time to time. Information from the Ministry of Lands indicates that under this programme, 250,000 plots have been allocated and surveyed in various locations in Kenya and a total of 4,475,870 title deeds issued since the inception of the cadastral system in 1903. Table 2.2 and Activity Diagram 2.2 (in Appendix 14) show all the steps involved in the processing of new grant surveys. Once the allocation process is completed, the documents are given to a Surveyor to carry out the precise survey of the allocated land plots.

The process of allocation of Government land has been based on the Government Land Act and was solely the prerogative of the President of the Republic of Kenya and the Commissioner of Lands. After the promulgation of the new Constitution, all the allocation responsibilities have been transferred to the National Land Commission. The process of allocation of Government Land will further change with the establishment of the devolved government system in Kenya in tandem with the requirements of the Land Act.

2.6.5 Cadastral Surveying Processes

Precise cadastral surveying processes in Kenya are normally carried out for new grant allocations or for setting apart of Trust Lands and subdivisions. The process is generally initiated by the Commissioner of Lands (CoL) or the Local Authorities when applications are received for land allocations, setting apart or subdivision schemes.

On receipt of such applications, the CoL requests for the preparation of a PDP depicting the intended transaction. For new grants and setting apart surveys, the Director of Physical Planning prepares the PDP. Whether the surveys are for new grants or subdivisions, the cadastral procedures are the same.

Once the PDPs have been prepared and approved, Surveyors proceed to carry out precise cadastral surveys guided by the provisions of the Survey Act. The first major item in the whole process is field data capture. The other steps involve compilation and submission of the survey project to the Survey department for checking, authentication and issuance of deed plan or amended Registry Index Map. Table 2.4 presents the details of cadastral data in the index card while Table 2.5 shows the processes of carrying out a precise cadastral survey. Activity Diagram 2.1 (in the Appendix 14) shows the activities of cadastral processing.

Table 2. 1 The Process of preparation of the Part Development Plan (PDP) (Source: Field work)

Function: Creation of New Parcels
Actors: Minster for Lands, Commissioner of Lands, Local Authority, Director of Survey, Director of Physical Planning, Permanent Secretary
1. Commissioner of Lands request Director of Physical Planning for preparation of Part Development Plan (PDP)
2. Request is forwarded through the Physical Planning Department Registry
3. Request forwarded to the Director of Physical Planning for authorization
4. Development Control Section prepares the PDP
5. Technical Section confirms status of the land parcel in the SPRO office and draughts the PDP
6. Development Control Section advertises completion of the PDP in the Daily Newspapers circulates and receives comments
7. PDP amended where necessary
8. PDP forwarded to the Director of Physical Planning for Certification
9. DPP submits PDP to Minister, through PS, for approval
10. Approved PDP sent to Registry of Physical Planning Department

The process of allocation of Government land has been based on the Government Land Act and was solely the prerogative of the President of the Republic of Kenya and the Commissioner of Lands. After the promulgation of the new Constitution, all the allocation responsibilities have been transferred to the National Land Commission. The process of allocation of Government Land will further change with the establishment of the devolved government system in Kenya in tandem with the requirements of the Land Act.

For many years, the allocation of Trust Lands was controlled by the Local Authority, the local Provincial Administration and to some extent by the Central Government through the Commissioner of Lands. Table 2.3 shows the many steps the setting apart procedure had to go through in order for land to be acquired for development. This process has been bureaucratic, slow and expensive. Since the promulgation of the new Constitution and subsequent implementation of the devolved government system, the setting apart procedure will now be carried out at the County level.

Table 2.2 The Process of allocation of Government New Grants (Source: Field work)

Function: Creation of New Parcels (F1)

Actors: Minster for Lands, Commissioner of Lands, Local Authority, Director of Survey, Director of Physical Planning, Chief Land Registrar

11. Various clients apply to the Commissioners of Lands for allocation of plots.
12. PDP is prepared and used for preparation of Letter of allotment under the GLA for Government land .
13. A Surveyor uses the Letter of Allotment as authority to carry out Title survey and sets out the parcel on the ground. Subsequently the survey is submitted to the Director of Surveys for checking and authentication.
14. Director of Survey checks and authenticates (or rejects) the survey. If authenticated, the DoS request the Licensed Surveyor to pay the checking fees, and submit the Deed Plans for authentication or RIM for amendment depending on the prevailing land tenure in the area.
15. Director of Surveys signs and seals the Deed Plans or the RIMs and forwards the same to the Commissioner of Lands for preparation and registration of the grant. In the case of the Local Authorities, the Town Clerk and the Mayor sign a lease document which is sent to the Commissioner of Lands for stamping (on payment of the stamp Duty) and registration.
16. The CoL signs the grant and forwards to the Chief Land Registrar (also referred to as Principal Registrar of Titles) to register and issues the grant to the allotee after payment of the requisite fees. If leasehold under the RLA, the allotee also signs the grant (attestation of Title) before it is registered. Under the RTA, the allotee does not sign the grant. For Local Authorities, the Commissioner uses the registered Lease Document to prepare a Certificate of Title against the head Title. Such leases are generally reversionary leases which expire a few days before the head title expires.

Table 2.3 The Process of Setting Apart of Trust Lands (Source; Field work)

1. The District Commissioner locates in consultation with the Local Authority identifies the site to be set apart and organizes for the preparation of a topo map of the site.
2. The plan is endorsed by the Local Authority and a notice of setting apart is given to the public.
3. The Council gazettes the setting apart notice for sixty days after which if there are no objections, the Local Authority passes a resolution for setting apart and such a resolution is gazetted by the Commissioner of Lands for 60 days.
   - (i) After the notice has been published, the District Commissioner requests the Director of Surveys to carry out a comprehensive cadastral survey of the site for allocation and title preparation. The Director of Physical Planning uses the final topo-cadastral to prepare the required PDP.
   - (ii) The Commissioner of Lands uses the signed Part Development Plan to allocate the land under the Government Lands Act, Cap 280 of 1915. Letter of Allotment is issued to the allotee with all the necessary conditions. Under the Local Authorities, the Town Clerk allocates the plot.
4. The District Commissioner thereafter notifies the residents in the area or any other person who may be affected by the setting apart that the setting apart procedure is to take place. The District Commissioner, with the assistance of the Land Control Board, invites applications for compensations
5. The District Commissioner assesses and pays compensations and informs the Commissioner of Lands of the total amount of the compensations.
6. Those claimants who are dissatisfied with the District Commissioner's awards or rejection of their claims are entitled to appeal through him within 30 days of notification of the awards to the Provincial Land Control Appeals Board and thereafter to the resident Magistrate's Court and the High Court under sections 10 (1), 10 (4) and 10 (5) respectively of the Trust Land Act.
7. Once the setting apart procedure is completed, the Director of Physical Planning prepares a Part Development Plan is used by the Commissioner of Lands to prepare a letter of allotment and the process now follows the same path as direct grant.

2.6.6 Land Adjudication Processes

The process of land adjudication was implemented in Kenya for the first time in 1954 and consisted of two main components: the land consolidation system and the systematic land adjudication. Land consolidation was first implemented in the Central Kenya Counties of Kiambu, Muranga and Nyeri. By mid-1962, nearly 300,000 farms had been consolidated and enclosed covering some 2.4 million acres of land [Rutten, 1992: 201].

Table 2.4 Contents of the index card (Source: Field work)

The Card Index contains the following information:-

1. The current land reference number and the original land reference numbers
2. The administrative district in which the property lies
3. The Meridional district for the area (this is done on reference to the standard Kenya map sheet lines)
4. The location of the survey with respect to the direction from the nearest township
5. The survey plan number (FR No) and the date of numbering
6. Areas associated with the plot. Those would include the gross area, the net area, reserved area (such as areas for roads and trigonometric stations).
7. Numbers of survey computations, field notes and checker's report
8. The name of surveyor who executed the survey
9. The deed plan number and the dates that it was signed, the deed plan blue print which was sent to the Commissioner of Lands, the deed plan which was issued and when the title was registered
10. The file used for correspondence in the Department
11. The land tenure (freehold or leasehold, the length of tenure and the statute under which the plot is registered).
12. Indication whether the plot has been subdivided at all.

Table 2.5 Precise Cadastral Processes (Source: Field work)

1. A Surveyor carries out the precise cadastral surveys which comprises, field data capture compilation and submission to the Director of Surveys for checking and authentication.
2. Director of Survey authorizes numbering and cross referencing of survey records.
3. Cross Referencing of Records
4. Preliminary checking
5. Final checking
6. Authentication of survey records
7. Preparation of Deed Plans and Registry Index Maps
8. Submission of Deed Plans or Registry Index Maps to the Commissioner of Lands for Title Registration

Immediately after attainment of political independence in Kenya, it was recognised that the land consolidation program was too slow to deliver titles urgently as demanded by the African Natives. The Government set up a Commission to institute a realistic programme for accelerating the land adjudication and registration programme and examine the extent of the resources needed to stimulate agricultural production. In November 1965, a team of six experts was appointed under the chairmanship of J.C.D. Lawrence to look into ways of solving the above issues.

The Commission published its findings in 1966 and some of the recommendations were that; the Land Adjudication Act Cap 283 of 1963 be renamed Land Consolidation Act Cap 283 of 1968, the Land Adjudication Act Cap 284 be created to cater for land adjudication in the non-scheduled areas, the Land Consolidation department was renamed the Land Adjudication Department in 1968, the Land (Group Representatives) Act was enacted to cater for the adjudication of group ranches, and amendments were done to the Registered Lands Act Cap 300 of 1963 and the Constitution of Kenya to incorporate the new statutes [Opuodho, 1974].

All processes of adjudication involving appointment of the respective officials and final processing of the documents are presented in Tables 2.6 an 2.7 and Activity Diagrams 2.5 and 2.6 in Appendix 14.

2.6.7 Land Subdivision Processes

The process of land subdivision in Kenya is controlled by two main Acts of Parliament: the Physical Planning Act, Cap 286, of 1996 and the Environmental Management and Co-ordination Act (EMCA) No. 8 of 1999. According to the requirements of the Physical Planning Act, all Local Authorities have the power to; prohibit or control the use and development of land and buildings, and control and prohibit the subdivision of land. All subdivision schemes have to be prepared and submitted to the relevant local authority by a registered Physical Planner.

For urban plots, subdivision scheme plans are also circulated to the relevant government authorities for approval. Once provisional approval is granted, the client pays the required fees and the survey documents are submitted to the Director of Surveys for checking and authentication. The provisional approval presents subdivision conditions to the clients which have to be fulfilled before titles are issued. The final approval is granted when the provisional conditions are approved. Once all the conditions have been fulfilled, a certificate of compliance is issued by the respective local authority and titles are prepared for the subdivisions, and such subdivisions are endorsed onto the original title [MoL, 1991: 27-29].

For the rural subdivisions, the local authorities would normally refer the applications for subdivisions to the District Land Control Boards first before commenting on the applications.
All rural subdivisions are therefore submitted first to the respective District Land Control Boards before the Local Authorities can provide their rulings. For large subdivisions, the National Environmental Management Authority (NEMA)[19] has to assess the scheme for environmental compliance before the Local Authorities can give the approvals. Tables 2.8 and 2.9 present a summary of the subdivision processes in the urban and rural areas respectively; while the activity diagrams for the respective processes are presented in Appendix 14

2.6.8 Title Registration Processes

UN-FIG [1995] defines land registration as the official process of recording of legally recognized interests in land. From a legal point of view, a distinction can be made between deeds registration, where the documents filed in the registry are the evidence of title, and registration of title, in which the register itself serves as the primary evidence of title. In this study only title registration was considered as the deeds registration system rarely involves precise cadastral processes.

Title registration defines the final stage of the cadastral processes in Kenya. It begins with the submission of the deed plans to the Commissioner of Lands. On receipt of these documents, the Commissioner enters the Land Registry Number and the Deed Plan in the register. The documents are then processed through various officers in the Ministry of Lands before the final title document is issued to the allotees as a legal document. The process of title registration

[19] NEMA operates under the EMCA and is headed by a Director General

consists of two main parts; the conveyancing part and the registration part. The conveyancing part is executed mainly by the Land Officers in the office of the Commissioner of Lands, and the registration part is executed by the registration officers in the office of the Chief Land Registrar.

Table 2.6 The Process of Land Consolidation (Source: Field work)

1.	On application of the Land Adjudication Act, Cap 283, in an area, the adjudication officer (originally the District Commissioner) was appointed by the Minister (previously the Provincial Commissioner) to carry out the land consolidation program in the area.
2.	Adjudication officer declares the area an adjudication section and carries out extensive public sensitization of the intended consolidation exercise until the local community agrees on the implementation of the consolidation program.
3.	Adjudication officer appoints a committee of 25 members from local resident and the Minister appoints an arbitration Board of at least 25 from the local residents, and an executive officer is appointed for each committee and each Arbitration Board
4.	Adjudication officer gives notice of the adjudication and six months for claims. After the adjudication of all the land claims, measurement of all the fragments is carried out to determine the area of each land fragment
5.	Record of existing rights is compiled showing, the names of the owner of the fragment (the ownership being determined by the committee), description and size of the fragment, any land set aside for public use for which compensation has been paid.
6.	If committee cannot agree on any issue in the adjudication area, it refers the case to the Arbitration Board who shall adjudicate the case and inform the committee of its decision.
7.	Record of existing rights is displayed in a public place for a period of sixty days during which, objections to its content may be lodged with the Executive officer of the committee.
8.	If the objection is to a committee decision the matter is referred back to the committee for second hearing and this second decision is subject to confirmation by the adjudication officer, who may confirm the findings of the committee or consider the matter with the arbitration Board. An objection on a decision made by the Arbitration Board is heard by the adjudication officer, assisted but not bound, by the arbitration board. The decision of the adjudication officer is final in either case.
9.	After the expiry of sixty days and when all the objections have been resolved, the record of existing rights is declared final and cannot be altered. At this point, the adjudication of existing rights is complete but without the benefit of mapping support.
10.	The Director of survey carries out aerial survey of the adjudication area to determine areas of the perimeter of the area and the fragments. The survey assumes that boundaries have been planted and are air visible. Production of base maps from the aerial photographs at 1: 5000 scale and enlargement to 1: 2500 scale, and computation of the planimetric area of the consolidation unit.
11.	The reconciliation factor is determined for the adjudication area. Each fragment is adjusted by the reconciliation factor appropriately
12.	The percentage cut factor is determined. This land is obtained from each fragment hence it is spread over all the land owners in the adjudication section
13.	The committee allocates land to each land owner in a single piece equivalent in area to the sum total of all his previous fragmented pieces after adjustment by the reconciliation factor and percentage cut.
14.	The consolidated holdings are demarcated on the ground in the presence of the members of the committee and the adjoining land owners in order to minimize the risk of corruption.
15.	In the demarcation process, the larger holdings are sited first and the smaller fragments are sited round the larger holdings. Roads of access are laid out for each holding and its fragments. The boundaries are then demarcated along their whole length by digging shallow trenches which are afterwards planted with live hedges and the final boundaries of the holdings are drawn permanently on the map
16.	Once the demarcation exercise is complete, a fair drawing of the field demarcation plans showing boundaries only is prepared. The drawing also incorporates any changes made and surveyed by the demarcation team during the demarcation in the field. Areas of the holdings are computed by planimeter.
17.	Once the demarcation map has been prepared, the adjudication register is prepared. This register contains every piece of land in the adjudication section by name and area. A note is also made of any encumbrances that may exist on the land holdings. Once complete, notice is given and the register kept in a public place for inspection for a further sixty days and objections are made to the adjudication officer. If one was not satisfied with the decisions of the adjudication officer, further appeal is made to the District Commissioner (now the Minister for Lands).
18.	Once the hedges have grown and are air-visible, new air photography, the re-flies, are taken. This mapping is for production of Registry Index Maps at a scale of 1: 2500, and without contours and showing cadastral boundaries only. The boundaries are then adjusted to accommodate objections or compensations are paid in lieu of alterations of the boundary
19.	After the expiry of the 60 days of objections a register of titles is prepared and negotiable freehold titles are issued by the Chief Land Registrar to each land holder under the Registered Lands Act Cap 300 of 1963. The RIMs substitute the demarcation maps at the Land Registry.

Table 2.7 The Process of Systematic Land Adjudication (Source: Field work)

1. Minister responsible for Lands appoints Adjudication officer to carry out land adjudication in an area.

2. Adjudication Officer appoints the Demarcation Officer, Survey Officer and Recording Officer for demarcating, surveying and recoding interests within an adjudication section.

   Adjudication officer declares the area an adjudication section and extensive sensitization is carried out several Barazas until the local community agrees on the implementation of the adjudication program.

3. Adjudication Department prepares a District "Stick-up Map" and identifies the approximate position of the adjudication section. The same topo maps are used are used as the index maps for demarcating the adjudication boundary onto the photo enlargements. The marked 1; 50, 000 topo sheets help in locating the centre points for the 1:12,500 and 1:25,000 photo prints commonly used for the adjudication.

4. The Adjudication Officer fixes a six months period for receiving claims. The notice further states clearly that with effect from the date, except with prior consent in writing of the Adjudication Officer, no person shall institute and no court shall entertain any civil proceedings concerning an interest in land within the adjudication section; until the adjudication register for that adjudication section has been finalized as per section 29 (3) of the Land Adjudication Act, Cap. 284.

5. When the process of demarcation, recording and surveying has been completed and all the cases before the Adjudication Committee and the Arbitration Board have been heard and decided, the Land Adjudication Officer sends the duplicate Adjudication register to the Director of Land Adjudication and also gives notice that the adjudication register has been completed and may be inspected at a given place for a period of sixty (60) days from the date of notice.

6. Any person who considers the registers to be incorrect or incomplete in any respect may lodge an objection (in writing) to the Land Adjudication Officer during the sixty day objection period. The Adjudication officer hears and determines such objections in his capacity as the third adjudication tribunal.

7. Any party aggrieved by the decision of the Land Adjudication Officer has the right to appeal to the Minister responsible for lands, who is the fourth and final adjudication tribunal. To speed up the disposal of pending appeals, the minister appoints, the District Commissioner (by a notice in the Kenya Gazette), to hear and determine land appeal cases in their respective districts.

8. When all objections have been heard and determined and decisions implemented, both on the ground and the original adjudication register, the maps are sent to the Director of Surveys for printing and computation of acreage. After the publication of the maps, the District Land Adjudication Officer dispatches the original adjudication register together with particulars of all objection decisions to the Director of Land Adjudication. On receipt of the register and details of objection decisions, the Director alters the duplicate copy of the register to bring it in line with the original register and certifies on both the original and the duplicate that the adjudication register has become final subject to outstanding appeals to the Minister.

9. On signing the certificate of finality, the Director of Land Adjudication sends the original register to the Chief Land Registrar for registration. It is from this register that the Chief Land Registrar prepares the register of titles under the Registered Land Act, Cap.300. The registration vest in the proprietors the absolute ownership of parcels of land registered in their names. After registration has been implemented, the Trust Lands Act ceases to apply in the registered area.

Table 2.8 Urban Subdivision Processes (Source: Field work)

1. Client requests for the subdivision and preliminary topo-cadastral plan undertaken to support preparation of Part Development Plan.

2. A Planner prepares a PDP and submits to the local Urban Authority together with Form PP1A and accompanied with a copy of the title deed to ascertain ownership and tenure status of the land.

3. The Local Authority approves the PDP, with a set of conditions, and issues Provisional Approval on Form PP2A to the Commissioner of Lands.

4. Commissioner of Lands gives a provisional approval to the client through the Physical Planner.

5. A Surveyor uses the Provisional Approval to carry out accurate subdivision survey and submit to the Director of Surveys for checking and authentication and deed plans or RIMs are released to the Surveyor on payment of the checking fees.

FINAL APPROVAL

6. A Planner applies to the Local Authority on Form PP1A attaching, a copy of the Deed Plans and evidence of compliance with the conditions of provisional approval.

7. Local Authority circulates the application to relevant institutions for ground inspection. and final approval is granted in Form PPA2 and Form PPA5 and a certificate of compliance is issued and forwarded to the Commissioner of Lands.

8. Commissioner of Lands issues a final approval.

9. With the Final Approval, client applies for subdivision certificate of compliance which is issued by the Local Authority. This certificate is also registered in the Land Registry and shows the IR number, the date and time of registration, signature and name of the registering g officer.

10. The client submits the all the relevant documents to a lawyer for preparation of the Title Deeds of each sub-plot.

11. Once the process is finalized, new subdivision titles are issued and the original title is endorsed with the subdivisions showing, the new LR Numbers, new owners, area of each subdivision and the file number of the transaction in Lands office. All these are endorsed in the original title of the property.

Table 2.9 The processes of subdivision of rural plots (Source: Field work)

1. Client requests for subdivision of rural land.

2. A subdivision scheme plan is prepared

3. A Planner submits an application to the District Physical Planner for the approval of the subdivision scheme plan together with Form PP1A.

4. District Physical Planner approves the subdivision sends back the document to the Local Authority with his recommendations.

5. Local authority circulates the application to relevant offices for comments.

6. Plan is approved with conditions attached; Form PPA2 is signed and sent to the Planner.

7. The Planner then submits documents to the Land Control Board for consent of subdivision.

8. A Surveyor carries out a comprehensive survey on the ground and places all beacons.

9. Survey is submitted to the District Surveyor, complete with mutation forms, for checking and amendments of RIM.

10. District Physical Planner issues form PP5 (Certificate of compliance) if he is satisfied that the survey is according to the approved scheme.

11. The District Land Registrar is then furnished with the Land Control Board consent, Form PPA2, Form PPA5 and a copy of the approved subdivision scheme plan.

12. Once the RIM has been amended, the Surveyor pays the checking fees and amended RIM is forwarded to the District Land Registrar for issuance of Title Deeds.

Table 2.10 The Conveyancing Processes of Title Registration (Source: Field work)

1. Director of Surveys delivers Deed Plans (DPs) or RIMs to the CoL Records office where LR or Parcel Nos are entered in the computer
2. Correspondence file are retrieved from the Archives and the DPs or RIMs are filed inside
3. File with documents taken to Senior Plans Records Officer (SPRO) and the new LR or Parcel Numbers entered in index cards and noted at the front of the correspondence file and on the Letter of Allotment.
4. File is passed to the relevant Lands Officer (LO) to give instructions to Registrar of Titles (RoT) for preparation of Title deed or Lease document which are taken to Registry for stitching, and the RoT instructs the typing pool to prepare the title deed.
5. RoT verifies the title deed and sends back to the Land Officer, who checks for completeness of the document
6. The title is then forwarded to the CoL for execution through various officers such as: the Senior Lands Officer, the Chief Land Officer, the Assistant Commissioner of Lands, the Senior Assistant Commissioner of Lands and the Deputy Commissioner of Lands
7. File is then taken to the Chief Land Registrar/Principle Registrar of Titles who authorizes the registration process and the file is taken to the RoT (conveyancing)
8. ROTs attests the signature of the Commissioner of Lands by signing the document and assesses stamp Duty payable.
9. Stamp duty paid, the file is taken to the accounts department for writing of Stamp Duty Certificate and confirmation that all the necessary fees have been paid.
10. Title is then taken to the stamping section to be either embossed or franked.
11. File is then taken to the Auditors (internal and external) to confirm that all payments have been made
12. File is taken to Survey Department for confirmation of the authenticity of the Deed Plans and the RIMs before registration is effected
13. New Grants are taken back to the ROT to book the title for registration.
14. Leases are passed over to the LO to write a letter forwarding the documents to the District Registries.
15. The allotees are then advised to collect the leases from the District Registries for their execution and attestation before a Lawyer and return to the Registry for registration
16. On confirmation by the Department of Survey of the authenticity of the deed plans and RIMs, the title is taken for registered.

Table 2.11 Title Registration Process (Source: Field work)

1. The Allotee applies to Registrar of Titles in Nairobi or Mombasa for registration of the title.
2. At the Central Registry, the application is given Day Book Number, time and date are entered on the document.
3. Title is taken to the Investigation Officer to assess whether it is registerable. This includes, checking if all the fees have been paid, the document is attested properly and the Commissioner has duly signed the title
4. File with all the registration documents are passed over to the Registration officer to check the details again
5. Registration officer proceeds to initiate the registration process; issuing of the IR No. or CR No. for Coastal properties.
6. Registrar also allocates entry Number against the IR or CR as the first main action on the Title (i.e. IR/1)
7. Deed File is opened, the Title document is stamped or Franked and entry is made on the title
8. Documents are passed over to the RoT to countercheck if all aspects of the registration process have been fulfilled
9. The Principal Registrar then signs the Title Deed and takes it back to the Central Registry for sealing with Government Seal
10. A photocopy of the Title Deed is prepared and it kept in the Deed File. The Deed File is then kept in the strong room of the Central Registry. This becomes the government copy of title such that incase of loss, a certified true copy can be prepared for the client after 60 days gazettement without claim.
11. Registered Title Deed is then released to the client as a legal document
12. After registration, the development plans are kept in the Senior Plans Records Office (SPRO), the parcel files are kept in the Records Office and the deed files are kept in the strong room in the registry at Ardhi house Nairobi
13. The Coastal Titles are registered in Mombasa and copies kept at the Mombasa land Registry

2.6. General Comments

The results of the cadastral structure and processes presented in this chapter indicate that the cadastral system in Kenya is bureaucratic, repetitive and cumbersome; a situation which does not support efficient land transactions and improved market economy. De Soto [2000] observed that the situation is similar in many developing countries; and translates into a loss of $ 9.3 trillion in untapped capital.

The Bathurst declaration [UN-FIG, 1999] that in order to achieve the objectives of sustainable development, current land information and cadastral systems need to be re-engineered or must continuously evolve to cope with the increasing complexities of human land relations. This is in line with the objectives of this study which seeks to find ways of re-engineering the cadastral system in Kenya so that service delivery can be improved.

CHAPTER THREE

STRATEGIES FOR A MODERN CADASTRAL SYSTEM

3.1 General Introduction

As a developing country, Kenya has achieved substantial economic development from the early establishment of the cadastre and a well developed land market. This chapter discusses the strategies for the development of a modern cadastral system in Kenya. It basically consists of two parts; a critique of the current system and presentation of Cadastre 2014 as a model cadastral system. The section below highlights some of the achievements of the system as identified by Nyadimo [1998], Njuki [2001], and Mwenda [2001].

3.2 The Achievements

3.2.1 Land Adjudication Programmes

The massive land adjudication programme initiated in Kenya in 1954 has enabled millions of indigenous Kenyans to acquire title deeds in a short time. Myles et al. [2009] have indicated that by the end of the 2010/2011, 1934 adjudication sections and 8.55million hectares of land (comprising 2.03 million parcels) have been covered. Additionally, 338 ranches (comprising 3 million hectares of trust land) have been registered.

The African Land Development Report (ALDEV) [MoA, 1962:235] indicates that prior to the adjudication programme, disputes over land-rights were decided by the African Courts; and the ill defined nature of customary rights in land had led to large volumes of litigations in the highly populated areas. For example, in Kiambu District, before the emergency in 1952, the court fees paid in respect of land cases amounted to £9000 per annum while in Kisii District (in 1955 alone), the expenditure was £13000. The process of land adjudication was therefore considered a major solution to the perennial land disputes and the attendant high costs.

3.2.2 Settlement Schemes and Cooperative Farms

At independence in 1963, the cardinal land policy of the Government was to transfer land ownership from White Settlers to indigenous Kenyans peacefully. To achieve this objective, many settlement schemes were initiated and indigenous Kenyans were given soft loans through the Settlement Fund Trustee (SFT) to buy land from the departing White Settlers. A department of land settlement was established in 1964 in the Ministry of Lands and Settlement to superintend over this exercise. The records at the Ministry of Land indicates that so far, the Government has settled 305,890 families in 469 settlement schemes, covering some 1,325 hectares of land.

Where the government was unable to purchase land for settlement in the White Highlands, Kenyans organized themselves into groups, formed companies or cooperatives, and bought land on a willing buyer willing seller basis. Initially, these farms were managed as single entities but due to political, social, and economic factors, the government decided to subdivide the farms into the individual shareholders. Under this programme, 2,700 cooperative farms covering an area of 2.2 million hectares have been subdivided resulting in the settlement or development by the respective proprietors.

3.2.3 Information Communication Technology (ICT) Unit

The Ministry of Lands, has initiated the development of an ICT unit whose main objectives are IT development, maintenance and computer operations. The unit is an initiative to implement e-government within the Ministry of Lands. The main vision of the unit is to host a joint-state-of-the art computer centre which would collaborate with other units in the government to facilitate easy transmission of spatial and textual data.

Through the unit, the government has initiated a process for digitization of cadastral records in all the departments in the Ministry of Lands. For example, the collection of land rent is currently being computerised in the department of Lands and all land rents are payable on-line. Currently, there are 500,000 land parcels under leasehold tenure from which land rents are collected. Already, the government has launched an Integrated Land Rent Information System which will enable citizens to pay land rent through the mobile phone system [MoL, 2010][20].

In total 32,000 RTA titles have been digitized by the end of December, 2009. Recently, the Government acquired three high speed scanners which can scan 100,000[21] copies per day. These new machines will greatly enhance the completion of computerization of land records in the Ministry of Lands.

3.2.4 National Land Information Management System (NLIMS)

National Land Information Management System (NLIMS) is a computer-based information system that enables the capture, management, and analysis of geographically referenced land-related data in order to produce land information for decision-making in land administration and management. In Kenya, it has been recognised that NLIMS would facilitate efficient and effective delivery of land and management services as spelt out in Vision 2030, the National Policy and the Constitution.

Since the year 2007 the Ministry of Lands recognized that a GIS-based NLIMS was central to the modernization of its functions and initiated the development a modern NLIMS in line with the government's new management principle of Rapid Results Initiative (RRI), a Results-Based Management tool by the Public Service Reform and Development Secretariat. This project was supported by SIDA and was estimated to cost Ksh. 3.8 Billion.

3.2.5 Computerization in the Department of Survey

In the Survey Department, systems have been established to capture any new cadastral data submitted in the department digitally and already; several cadastral plans, deed plans and several computation files have been scanned and stored in the computer. A Computer

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[20] Official Communication from the Minister of Lands in the Daily Nation, Wednesday, March, 19th 2010.
[21] Presentation by the Commissioner of Lands to the ISK seminar on Thursday, 2nd July 2010 at the Hilton Hotel, Nairobi.

Aided Mapping (CAMP) section has also been set up to handle digital photogrammetry, GIS, and digital Mapping. The section captures and digitizes urban plans, Registry Index Maps and special maps that are required for several operations. All these data are captured in the Kenya Cadastral Information System (KeCIS) which runs on Microsoft Access Database. The database is mainly used to document and track the cadastral surveys submitted to the department.

The department recently tendered out the digitization and revision of topographical maps to the Regional Centre of Mapping for Development and so far, all the topographical maps have also been scanned and are currently being up-dated with high spatial resolution satellite imagery. The department has also finalized and published a digital National Atlas of Kenya and is currently digitizing aerial photographs. The department however, still does not have a modern cadastral database that would facilitate seamless exchange of information.

3.2.6 Kenya National Spatial Data Infrastructure (KNSDI)

National Spatial Data Infrastructure is the technology, policies-standards and institutional-framework which facilitate easy availability, access, seamless sharing and dissemination of spatial data across all levels of government, the academia and the private sector. It is a vital tool for the development of various sectors of the economy.

The World Summit on Sustainable Development (WSSD) and the United Nations Economic Commission for Africa (UNECA) have both recognized the need to promote the effective and efficient use of spatial data as a necessary requirement in support sustainable development of any nation. Kenya therefore, has the responsibility of establishing a national repository of its spatial data holdings and to provide the mechanism for its access, sharing and dissemination.

3.2.7 Development of a National Land Policy

The draft National Land Policy [MoL, 2007] has been formulated in a process of nationwide consultation and was formerly enacted into Law in December 2009. As stated in the Draft Land Policy Document, Kenya has not had a single and clearly defined land policy since independence. The approval and subsequent publication of the Sessional Paper No. 3 of 2009 is therefore a major milestone in the management of land in Kenya. MoL has established a Land Rights Transformation Unit (LRTU) in readiness for the implementation of the land policy.

After the promulgation of the new Constitution on the 27th of August 2010, the Government has proceeded to implement the new land policy by enacting three Bills into Law. These are the National Land Commission Act No. 5 of 2012, the Land Act No. 6 of 2012 and the Land Registration Act No. 3 of 2012 respectively. Two additional Bills; the Community Land Bill and the Eviction and Resettlement Procedures Bill 2013 are at the drafting stage and will soon be forwarded to Parliament for debate.

3.2.8 Development of Unique Parcel Identifier

Currently, there are as many as seven parcel identification systems in Kenya and with local variations. Parcels created under the GLA and RTA are given Land Registry (LR) numbers. These are numerical identifiers with no reference to location. Under the RLA parcel identification is based on the Parcel Number referenced according to district, location, registration block and then the number itself.

Neither of these systems is ideal for geo-referencing for computerization purposes. ParcelID are assigned by the Survey Department, and are frequently used by many other organizations for operations. These include Lands Department, Land Registries, Banks, Municipalities, County Councils, private landlords and tax collection agencies. The lack of a unified standard for parcel identification makes the exchange of parcel based information a difficult task. MoL has recently initiated a process, within the NLIMS Project to develop a unique ParcelID suitable for computerization of the land parcel within the cadastral models.

3.2.9 Mapping of the Exclusive Economic Zone

The importance of the marine environment to human existence makes it imperative that information models are developed in order to improve good ocean governance. The

United Nations Convention on Law of the Sea of 10th December 1982 (UNCLOS) has provided a legal mechanism by which nations can extend their marine claims as far as the end of the continental shelf [Ng'anga' et al., 2001].

The Exclusive Economic Zone (EEZ) under the control of Kenya extends about 200 nautical miles into the Indian Ocean. The boundary of this EEZ has been delineated on the navy marine charts and gazetted by the Government via Kenya Gazette Notice No. 22 of 22nd July 2005 (Legal Notice No. 82 and Legislative Supplement No. 34). This proclamation was deposited with the United Nations Secretary General and is contained in United Nations Law of the Sea Bulletin No. 61. It contains exclusively, an illustrative map of Kenya (SK 90 Edition 4) and two lists of geographical coordinates of points specifying the straight baselines from which the breath of the territorial sea and the outer limits of the EEZ may be measured [GoK, 2009].

3.2.10 Development of a Modern Geodetic Reference Frame

The international benchmarks such as the Cadastre 2014 require that cadastral systems be based on a uniform geodetic reference system which ensures seamless exchange of spatial information internationally. In Europe for example, thirty six International Terrestrial Reference Frame (ITRF) stations were selected in 1989 to create the European Reference Frame, the ETRF 89 [Konecny, 2003].

This reference frame now serves as the basis for re-observation of national geodetic frameworks in Europe with differential GPS and serves as a new tool for up-dating the local cadastral surveys. In Kenya, the government is currently in the process of establishing 25 zero order and 75 first order Continuously Operating Reference Stations (CORS) to achieve the following operations; support the development of a modern geodetic network in Kenya, enhance cadastral mapping in the country, and promote the development of a computer-based cadastral data processing system.

3.3 Challenges Facing the Cadastral System in Kenya

As the government decentralizes its operations to the county level in light of the new constitution, the demand for accurate and up-to-date spatial information will increase immensely. The Government therefore needs to develop a series of linked requirements in order to effectively control economic development at all levels of the economy. It also requires a well established institutional framework at the centre and a decentralized decision-making capacity at the lower levels.

Fulfilment of these needs requires access to adequate and reliable geospatial information for the implementing of economic policies at all levels of operation. The problem is that currently, the process of doing business with land in Kenya is quite slow. In a report entitled *Doing Business 2013: Reforming through Difficult Times* of the World Bank, Kenya has dropped from position 12 to position 121 in the World's global list of economic competitiveness.

3.3.1 The structure of the system

The 19th Century land administration systems established single function cadastral systems which consisted of the Commissioner of Lands, Director of Surveys, the Chief Land Registrar and the Chief Valuer. This structure is rigid and non-compliant with modern administrative requirements. It has therefore become necessary to reorganize these administrative structures to be in line with modern management principles to provide for: (i) more competitive professional services and private sector involvement, and (ii) capitalize on opportunities available from digital and web-based technologies.

In Kenya, the cadastral administrative system has remained the same for the last one hundred years and yet new management principles require a re-adjustment of the cadastral management systems in order to provide efficient services in the 21st Century. The combination of new management styles, computerization of activities, creation of databases (containing a wealth of land information, and improved interoperability of valuation, planning, address, spatial and registration) allow for much more flexibility and improved cadastral production.

3.3.2 Land Tenure System

The draft land policy [MoL, 2005] notes that land in Kenya is a primary resource and the basis of livelihood for the people. It should therefore be held, used, developed and managed in a manner which is equitable, efficient, productive and sustainable. According to Juma and Ojwang [1996; 22] privatization of land in the African reserves failed to deliver the objectives of the Swynnerton Plan which were: (i) security of tenure, (ii) improved access to credit, (iii) reduced land conflicts, (iv) economic size of land holding, (v) an effective land market, and (vi) incentives for investment and sound resource management.

The formal tenure has resulted in several problems; fragmented and sub-economic land units, tenure insecurity due to the existence of overlapping land rights especially at the interface between rural and urban areas, a rise in levels of poverty and landlessness due to lack of capacity to gain access to clearly defined, enforceable and transferable property rights, gross disparities in land ownership with regard to gender and minority groups, and inadequate provision of the essential infrastructure which inhibit sustainable development of rural areas. There is therefore a good case for tenure modernization.

3.3.3 Digital Land Information

Williamson [2005] observed that the growth of complex commodities offer huge potential for cadastral systems; and it is land information that offers the facility for transforming the way future governments and private sector will do business. The potential offered by land information in areas such as virtual world, Google Earth, cloud computing and Microsoft's Virtual Earth are just beginning to take effect. Availability of digital land information places the growth and impotence of geosciences alongside nano technology and biotechnology as transformational technologies in the decades ahead.

In Kenya, because land information is still kept in manual format, the system is not only inefficient in land data management but is also beset with inadequate storage space. This hampers quick cross-referencing of records and constraints the orderly and timely updates of databases in use. In this state, data and information are not easily accessible, and as a consequence, important decisions on land can be made on unreliable information. It is necessary therefore for the government to develop an integrated land information system so that land management can be operated efficiently.

3.3.4 The Cadastral Data Models

Lemmen et al. [2003] have observed that cadastral modelling is a basic tool for facilitating appropriate systems development and re-engineering; and forms the basis for meaningful communication between different parts of the system. Cadastral data modelling is therefore instrumental in the establishment of a multi-purpose digital cadastre. It also improves the database integrity by maintaining logical, temporal and topological consistency.

Kenya however lacks a modern cadastral model, a situation which has contributed to several problems in the land administration system. The current effort at creating a digital cadastre has not culminated in the development of comprehensive cadastral model as the parcel information contained therein are only spatial information in the traditional cadastre without attributes. There is therefore a case for the development of GIS-based system which integrates the Property Register, cadastral maps, and legal surveys into one whole system of information system.

3.3.5 Land Parcel Boundaries

Deininger [2003: 27] has observed that precise, observable and well defined boundaries are easier to enforce and costs less to protect than poorly defined boundaries. A relatively vaguely defined boundary is respected as long as the institutions which can interpret the boundary are available. Once such institutions are absent, interpretation of such boundaries fail and conflicts occur.

Currently, Kenya operates three boundary systems: the fixed boundary, the general boundary, and the fixed-general boundary. The fixed boundary system conforms to the requirements of the international benchmarks such as Cadastre 2014 model as it is geo-referenced onto a geodetic reference system. The general boundary operates in the enclosure system[22], where boundaries are defined by physical features. There is a need to georeferenced to minimize disputes and enhance the real estate market.

3.3.6 Land Registration Systems

The Bathurst Declaration [UN-FIG, 1999] recognises that the main function of a land registration system is to provide security of tenure and allow for efficient transfer of rights in land as support for a land market. Williamson [2005] however observed that apart from enhancing security and land market, there are many rights, restrictions and responsibilities relating to land, which need to be formalized for achievement of sustainable development.

The land registration system is en-cumbered by several issues; it operates both deeds and title registration systems although the former was supposed to have been repealed, there are several registration laws operating at the same time, which are confusing to both the practitioner and the user, it is encumbered by a bureaucratic centralized administration process, and it does not recognize the indigenous land rights and the informal land tenure.

3.3.7 Slow Adoption of Modern Technology

Slow adoption of modern geospatial technologies in cadastre (GPS, Remote Sensing and GIS) is one other major weakness of the cadastral system in Kenya. While many countries have adopted modern methods of cadastral mapping, Kenya still relies on traditional methods for cadastral survey. Geospatial data exchange and transmission are hampered by lack of modernization in the cadastral sector and spatial information is still exchanged in the analogue format. This scenario is not conducive to the implementation of the e-government and achievement of the objectives of Vision 2030.

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[22] Enclosure system refers to the land reform in Europe in the 1700s. The system consolidated the tiny feudal land units into larger and more productive plots [Ting, 2002**]**.

There is therefore a clear case for the adoption of modern technologies in data acquisition and modelling in the cadastral systems in Kenya. While the government has initiated the adoption of e-government in several sectors of the economy, the land sector is still heavily analogue in its operations.

3.3.8 Duplication of Land Information

The new vision of the cadastral system envisages a modern cadastral infrastructure which facilitates efficient operation of the land and property markets and supports seamless exchange of geospatial information across the globe. Lack of collaboration between various spatial information stakeholders across any country results into duplicated management of the land information and impedes the implementation of the objectives of a modern cadastre. Usually this problem arises when spatial information are collected and maintained by different government organizations. In Kenya, this situation is rampant in several Government Ministries where most of the spatial information is duplicated resulting in a lot of data redundancy and a waste of resources.

3.3.9 Low Cadastral Coverage

Currently, one of the international global challenges is to develop economies that support sustainable development and environmental conservation. As De Soto [2000] observed, any delays in the documentation of any part of land within any jurisdiction impedes access to formal credit and frustrates efforts towards maximum exploitation of natural resources.

In Kenya, the cadastral system covers only the 20% high potential areas of the country while the rest of the land is largely held as trust lands where the local county councils administer the land on behalf of the resident communities. As such, large majority of Kenyan population have effectively been disenfranchised without their consent. There is therefore an urgent need for the government to fast-track the adjudication programme in the rest of the country in order to bring all land onto the register.

3.3.10 Lack of 3D Cadastre

In Kenya, both the technical and legal aspects of 3D cadastre are lacking. The closest approach to this property definition is the Sectional Property Act No. 21 of 1987. The problem however is that under the Sectional Property Act, footprints of the buildings are coordinated in 2D and the rest of the vertical units are coordinated based on the vertical projection, where the upper corners are assumed to be vertically aligned to those directly below them.

This assumption is not always true as there are instances where walls may not be vertical and floors may not be lying in the same horizontal plane. In these instances, the application of Sectional Properties Act as practised in Kenya today fails and the titles issued become unreliable. There is therefore a need to develop both technical and legal aspects of 3D cadastre models for realistic representation of land rights in Kenya.

3.4 Evaluation of the Cadastral system

The evaluation of the cadastral system was based on international benchmarks developed by Steudler [2004], UN-FIG [1995] the Bogor Declaration [UN-FIG, 1996], and the Bathurst Declaration [UN-FIG, 1999], Enemark [2001], Kauffman and Steudler [UN-FIG, 1998], Dale and McLaughlin [1998], also provided vital internationally accepted good practices in cadastre. Based on the above benchmarks, a Logical Framework Approach (LFA)[23] was used to evaluate the performance of the cadastral system in Kenya against internationally accepted standards. A table presenting the results of the evaluation is presented in section 5.1 in Chapter Five.

3.5 Cadastre 2014 Model

Cadastre 2014 was initiated at the 20th FIG Congress, in Melbourne Australia, in 1994, as an international benchmark for cadastral systems. It was published in 1998 and has since

[23] Logical Framework Approach (LFA) is an instrument for objective-oriented planning of projects. It is commonly used for objective evaluation of projects and has been recommended as a useful tool for the evaluation of cadastral systems.

been translated into several languages. At the heart of Cadastre 2014 are six statements about the future of cadastral systems.

Statement Number One expects the future cadastre to show the complete legal situation of the land in terms of rights, restrictions and responsibilities. While this is possible in the developed counties, in Africa and many other developing countries, this is not currently possible because majority of land rights are customary and are not necessarily expressed in Western judicial systems. It is therefore not possible to implement this statement this statement in the developing countries without extensive modifications to the existing cadastral systems.

Statement Number Two is concerned with the integration of maps and registers to provide one complete database for simless exchange of land information. This is the situation in most countries still operating traditional cadastral systems. This is mainly due to the fact that cadastral surveying and mapping require specialized technical skills in order to attain sufficient accuracy for mapping while land registration needs more of administrative skills.

The advantage of this arrangement is the cross control mechanism that helps to minimize errors in the land transactions. The disadvantages however are that the system is bureaucratic and duplicative as clients have to shuttle between different organizations for services. The information kept by the different organizations is redundant, and expensive as the different organizations charge for services for the same data. This is the current situation in the Kenya cadastre which this study seeks to provide solutions.

Statement Number Three implies that under the traditional cadastre, cadastral map defines the database. While it would be necessary for cadastral maps to address as many users as possible, it is virtually impossible for the current map to address all the required interests of users. This is mainly due to; the changing spatial and legal status of the cadastre all the time, the steady accumulation of survey observations, the multiple demands of a multipurpose cadastre, the fast changing role of the cadastre in a globalized economy, advances in Information Communication Technology (ICT), and developments in GIS which continue to change the way in which information is structured, stored, managed, delivered and used.

Data modeling therefore presents an opportunity to re-engineer the present cadastral systems so as to tackle a wide range of problems. The problem however is that for cadastral modelling to succeed, several adjustments have to be made to existing land administration systems in the developing countries. These include; provision of cadastral information on a uniform geodetic datum, availability of a well defined and comprehensive coordinate system, availability of fully digitized and georeferenced spatial data, existence of a comprehensive Spatial Data Spatial Infrastructure, and a modern administrative set-up and efficient data communication protocol.

Unfortunately, in most developing countries, most of these tools do not exist hence development of modern cadastral models will delay and the paper format will persist for some time. It will therefore take a while before statement number three is fully implemented in the developing countries.

Statement Number Four assumes that the traditional cadastre based on pencil and paper will disappear and will be replaced with a computerized cadastre involving structured Land Information Management Systems, and cadastral databases. Full digitization of spatial data however, raises the issues of electronic signatures and data security. Steudler [2004] has summarized an elaborate ISO certification for Land Management Information Systems, Cadastral Database Management Systems and general security of the spatial data.

In many developing countries, these systems do not exist both in terms of technology and human capacity. Additionally, in many developing countries, land tenure systems are mixed and complex. In African countries, for example, western-focused standards may not fit the cultural environments in the developing countries. Therefore, the move from paper to computerized cadastre may not be implemented soon in many developing countries. Apart from purely technical issues, there are serious tenure and administrative issues that have to be assessed and managed before full computerization can be implemented.

Statement Number Five seeks to promote public private partnership in the management cadastral systems. However, this arrangement requires that the private sector carries out all surveys of private land and most government contracts. The private sector is also expected to be involved in all land subdivisions, site surveys and designs, engineering and infrastructure surveys. The public sector on the other hand is expected to; provide supervisory and administrative control of cadastral surveys by setting standards and policies, approving and auditing in-puts, maintaining the records, and maintains geodetic control networks.

While government regulations and maintenance of systems is often perceived as a cost, it provides significant benefits to surveyors and their clients; in that it ensures common and consistent standards. The control system also ensures the ability to share and reuse survey information, and to retrieve survey marks and information.

Further benefits arising from the statutory framework is the partnership and shared responsibility of the private and public sector for the integrity and efficiency of the cadastral survey system, and consequent security of property boundaries and reliability of the generated land information. Development of cadastre databases further enhances data sharing and automatic data transfer in the internet platform. The registration of surveyors by the Land Surveyors Boards also provides further quality control on surveyors and maintenance of quality standards in field operations and data presentation.

Kenya is one of the countries where private partnership has evolved for close to a century. The first private surveyors were engaged in private cadastral surveying at the inception of the cadastral system in Kenya in 1903, and Kenya today boasts of a well developed private sector consisting of a pool of private Licensed Surveyors involved in various sectors of the economy. Private cadastral surveyors in Kenya are responsible for all subdivision surveys, government new grants, rural subdivisions (mutations), and all kinds of engineering surveys and environmental mapping. Thus private public partnership is already well implemented in Kenya.

Statement Number Six implies that spatial data will be taxed in order for the government to raise revenue, and indeed the initial cadastres were developed specifically for tax collection. This is one area where the Kenya cadastre has done well as cost recovery system has been in operation since the establishment of the system in 1903. While the government has provided the bulk of the funds for administrative operations of the system, the private sector and the public always pay for the services. Some of the operations charged for cost recovery include, payment for letter of allocation, survey fees, conveyancing, stamp duty on transfer, land registration mortgages, charges, lease extension, approvals and any transaction inland in Kenya.

3.5.1 Cadastre 2034

Bennet et al. [2011] have observed that over the last thirty years, spatial information technologies and sustainability theory drove the creation of new visions, models and roles for the cadastre. Concepts such as the multipurpose cadastre, Cadastre 2014, and sustainable land administration radically altered the understanding of cadastre and its potential. Many of these concepts continue to be relevant in the contemporary context; however, for cadastral science to remain relevant, researchers must look to the future and formulate new policy guidelines for the future cadastre.

In this regard, the researchers pioneered preliminary research into the future cadastre and came up with a new cadastral 2034 Model which looks at the nature of cadastre in the year 2034, twenty years from the expiry date of the current Cadastre 2014 Model.

The proposed Cadastre 2034 Model will be governed by six new statements; Survey-Accurate cadastre where communities will move from general boundaries to fixed boundaries, Object-Oriented Cadastres where the focus will shift from land parcels to property objects, 3D and 4D cadastre where height and time will be incorporated into the cadastral frame-works to support the dynamic markets, Real-Time cadastres where spatial information will be updated and accessed in real-time, global cadastre with capacity to link into regional and global cadastral networks, and organic cadastre which will better model the organic natural environment where properties are designed around natural phenomena rather than the strict bearings and distances.

3.5.2 A Critique of Cadastre 2014 and Cadastre 2034

Although Cadastre 2014 proposes a radical departure from the traditional parcel-centric cadastre, and fronts a land object centric approach, it has several weaknesses. It is, for example, wholly based on the fixed boundary system while majority of boundaries in Africa are general and non-mathematical. This is a major problem we have in Kenya at the moment and the government intends to solve the problem through georeferencing as proposed in the new Land Registration Act.

Cadastre 2014 does not address the informal and customary land tenure systems which are prevalent in the developing countries. It is also complicated and ambitious for African countries as its application requires a well developed technical capacity and human capital. De Soto [2000], El-Sioufi et al. [2010] and McLaughlin [2010] have also observed that it was published before the adoption of the Millenium Development Goals and climate change agenda. Cadastre 2014 therefore is currently inadequate in providing the international benchmark it was initially intended for.

3.5.3 A Summary

In summary, it can be concluded that cadastre 2014 was ambitious for most developing countries and all the statements cannot be fully implemented. What is emerging is that Cadastre 2014 was influenced by John McLaughlin's multi-purpose cadastre concept of 1975; Cadastre 2014 does not explicitly refer to land governance as an issue. Its strengths however lie in three main areas; its success in raising awareness and encouraging on cadastre internationally, its capacity to foster a broad multidisciplinary and cross-sectional dialogue across the globe, and promoting the focus of the World Bank and the United Nations on land governance to fore-stall the merging global land-grab rush.

The proposed Cadastre 2034 on the other hand proposes radical changes to the world cadastre even before many countries in the world have implemented Cadastre 2014. However, there are new challenges in the world which the cadastre has to address. These include; challenges of poverty, environmental protection, good governance, and economic stability. This study however observes that as Cadastre 2014 continues to play a benchmark role for most world cadastral systems; important aspects of Cadastre 2034 should be picked and applied in tandem with Cadastre 2014. This way, the developing countries will have the benefit of utilizing the two benchmarks concurrently as they strive to modernize their cadastral systems.

CHAPTER FOUR

REASEARCH DESIGN AND METHODOLOGY

4.1 Evaluation of the Cadastral System

This objectives of this study are; to evaluate the current cadastral system in Kenya, identify and analyze the appropriate techniques and strategies for the future needs of Kenya's Cadastre and to test the suitability of the identified techniques and strategies in the Cadastral System. The research design was carried out as follows. First, it was considered prudent to first evaluate the organizational structure and the processes of the cadastral system in order to assess its strengths and weaknesses. This would then form a basis for the design of the modernization strategies.

This approach is in line with internationally accepted practices. Dale and McLaughlin [1988] have, for example, indicated that before any meaningful improvement can be made to any cadastral system, there is need to evaluate the manner in which the present system operates. The Bogor Declaration [UN-FIG, 1996] has observed that before a system is improved, it is important first to identify the bottle-necks, inefficiencies and duplications of the system. Once the processes have been fully documented and understood, it is then possible to improve the efficiency and effectiveness of the system in service delivery.

Enemark [2001], Kauffman and Steudler [1998], Dale and McLaughlin [1988], and Steudler [2004:69-105] have provided internationally accepted guidelines to support evaluation of any cadastre. Based on the guidelines, this study selected a few performance indicators to guide the evaluation process. These included; the organizational structure, technical aspects, legal and Financial Aspects, security, simplicity, timeliness, accessibility, cost, and sustainability.

Apart from the above performance indicators, statements listed in Cadastre 2014 Model were also adopted in the evaluation process. According to Kauffman and Steudler [UN-FIG, 1998], these statements have a strong impact on the development and performance of cadastral systems and are important in the design of the evaluation of any cadastral system.

The main parameters evaluated from the Cadastre 2014 Model included; the legal situation of the cadastre including rights, restrictions and responsibilities, spatial data integration, level of cadastral modelling, private and public partnership, and cost recovery.

In carrying the evaluation of the cadastral system in Kenya, the following approach was adopted; a review of relevant literature on the cadastral system in Kenya from the departments in the Ministry of Lands, local and international sources; oral and questionnaire interviews with Land Surveyors and Lawyers, users of land information from the Ministry of Lands; and members of the public who interact with land information on a daily basis, and evaluation of several cadastral processes that are commonly associated with cadastral operations in Kenya. The results of the evaluation are presented in chapter Five of this thesis.

4.2 Testing of Geospatial Technologies

The Geomatics Industry Association of Canada (GIAC) defines geospatial technologies focusing on the acquisition, storage, analysis, dissemination, and management of geographically referenced information for improved decision making [Thurston et al., 2003]. These technologies include the Global Positioning System (GPS), Geographic Information System (GIS), Remote Sensing (RS) and Photogrammetry.

The Bathurst Declaration [UN-FIG, 1996] noted that modern data acquisition technology is making data capture easier and cheaper, resulting in more efficient land surveys. This is important since mapping and updating of spatial data are costly activities. GPS technology is already making land surveying field activities cheaper, as has been the case with aerial photography, while the use of high-resolution satellite imagery have been found appropriate for resource mapping.

It was considered prudent to test the suitability of selected geospatial technologies in cadastral surveying because; these are the tools that currently support modernization strategies of any cadastre. The Bogor Declaration [UN-FIG, 1996] observed that re-engineering of cadastral systems often require the use of modern technologies amongst other issues. Sessional Paper No.3 of 2009 [GoK, 2009] has noted that the current cadastral system in Kenya still hampered with slow, cumbersome and out-dated modes of operation which hamper quick data access and transfer.

The study therefore carried out tests on GPS, High Spatial Resolution Satellite Imagery in selected study sites as shown in Figures 4.1 and 4.7. This stage involved testing the geospatial technologies to asses their suitability in cadastral mapping and modelling. GPS and Remote Sensing methods were tested in Kwale and Machakos Districts respectively while the GIS was tested in Mavoko Municipality close to the city of Nairobi. The results of these tests are presented in chapter Five.

4.2.1 The GPS Technology

This section discusses the application of Global Positioning System (GPS) in cadastral mapping in Kenya. The application is based on a selected representative study site in Kwale County (Fig. 4.1) where there were available adequate data for the analysis and evaluation of the GPS project. Available literature indicate that currently, GPS is becoming conventional equipment in cadastral mapping in different parts of the world [Kardiasmenos, 2005; Eckl and Barnes 2002; Londe, 2002; and Rizos et al., 1999; Roberts, 2005]. However, in Kenya, the use of this technology in cadastral mapping is still scanty.

GPS is a satellite-based radio-positioning and time-transfer system developed by the U.S. Department of Defense to support real-time navigation anywhere on the Earth. The system has the advantage of being globally accessible, functioning independent of the local weather conditions, and being able to provide three dimensional position, velocity and time in a common reference system, anywhere on or near the surface of the Earth, on a continuous basis.

4.2.2 Point Positioning

If one receiver is used to determine the absolute coordinates of any point on Earth, with respect to the reference frame WGS–84, the positioning technique is known as *single point positioning (SPP).* This technique can be further divided into two classes depending on the assessment used, namely *pseudorange-based point positioning* and *carrier phase –based point positioning.*

In the pseudorange–based point positioning mode, the basic principle is to use resection by distances to determine the receiver's coordinates. If the satellite coordinates are assumed to be known (as they are provided to the user within the navigation message), the receiver's coordinates can be computed form the resection using the measured pseudoranges. The accuracy of this the pseudorange–based SPP is currently about 7 meters in the horizontal component and 12 meters in the vertical component (at the 95% confidence level) for civilian users.

Due to the availability of precise GPS orbits and satellite clock corrections, precise carrier–phase based SPP has recently been proposed by the Jet Propulsion Laboratory. This technique mainly uses the carrier phase measurements form both frequencies (L1 and L2) with the post–mission information in the estimation procedure, producing high–precision positioning results. It requires a reasonably large amount of data, implying that *instantaneous* solutions are not yet possible, and currently can only be used when the receiver is stationery.

4.2.3 Relative Positioning

In the relative positioning method, sometimes also referred to as to as *differential positioning*, two GPS receivers are used to observe the same satellites simultaneously. One receiver, designated as "the base" is set up at a reference station whose coordinated are known. The other receiver, designated as "the rover" is used to determine its coordinates with respect to the reference station. In this case, by subtracting the observations at the reference station from those at the rover, the *single – difference* equations are derived from Equations.

This technique reduces many of the systematic biases (e.g. satellite orbit bias, satellite clock error, ionspheric and troposphere delays), and is extensively used in data processing schemes for applications requiring centimeter level accuracy. However, the effectiveness of the relative positioning technique is largely dependent on the distance between the two receivers. The residual error increase as the distance between the receivers increases.

Relative positioning can further be divided into two classes depending on the measurements used, namely *pseudorange – based differential positioning* and *carrier phase based* *differential positioning.* The pseudorange–based differential positioning method is commonly referred to as Differential GPS (DGPS). The estimation of the range error for each satellite is carried out at the reference station. The estimated range errors (or corrections to the measurements) broadcast to the users by an appropriate communication link [Roberts, 2005] for operations over a small area one reference station is typically used, and the technique is generally referred to as *Local Area Differential* GPS (LADGPS).

If a network of reference stations is employed to generate the range corrections for each satellite, the correction data model is valid over a much larger area, and the technique is referred to as *Wide Area Differential GPS (*WADGPS*).* Finally, in a case where the geostationary satellites transmits to users the DGPS corrections for each satellite, together with additional GPS–like ranging signals and an integrity, message, the concept is known as *Wide Area Augmentation System* (WAAS). Detailed explanations of these DGPS techniques can be found in Kardiasmenos [2005].

Carrier phase–based differential positioning is realized by either differencing the carrier–phase measurement made to the same satellite by two receivers, at the same time, or differencing the carrier – phase measurements to two satellites made by the same receiver, at the same time. The former method is referred to as *single – differencing between receivers* while the latter is referred to as *single–differencing between satellites.* If the difference between the single–differenced observations is informed, a process referred to as *double–differencing,* the resultant double differenced observable is the standard input for carrier phase based data processing.

Carrier phased–based differential positioning can be carried out in static or *Kinematic mode*. If carried out in kinematic mode, the technique is referred to as *kinematic positioning,* implying that either (or both) the reference and use receivers are in motion (1985). Today, with advanced receiver technology and improved data processing algorithms, it is possible to obtain high precision result (sub-cm) in real-time using the “Real-Time Kinematic” (RTK) GPS positioning method.

4.2.4 GPS-RTK Positioning

Although differential GPS positioning provided sub centimeter level accuracy, high accuracy is not possible in real time. The capacity to achieve cm-level positioning in real-time was achieved when radio-link was incorporated between the base and the rover stations. This approach in GPS measurements is known as Real Time Kinematic (RTK). The cm-level precision of the RTK relies on the "initialization process" which depends on the Ambiguity Resolution in the double differencing GPS measurements. In the initialization process, two simultaneous "one-way" carrier phase measurements are logged at two antennas to the same constellation of satellites. Roberts [2005] has reported that this procedure identifies a base satellite and forms pairs comprising two satellites and two antennas with the base satellite common to all pairs.

One way carrier measurements are similar to EDM measurements in that the distance between a satellite and antenna is the sum of an unknown number of waves (in this case, the L1 GPS signal with a wave length of 19cm) plus a fractional part which is measured and continuously tracked by the GPS receiver. Separate channels in the GPS receiver "lock on" to separate satellites and count the number of wavelengths either increasing or decreasing for a setting of satellites or rising satellites respectively. Any interruption on this counting procedure, such as when a satellite tracks behind an obstruction, is called a "cycle slip." Combining four one-way phase measurements is the process of double differencing and serves to eliminate the cycle slip error.

Double differencing is also used to aid the computation of the unknown number of wavelengths between a satellite and a receiver (the ambiguity) at the moment of the first simultaneous measurement of both GPS receivers. This process is known as "Ambiguity Resolution" (AR). Initialization is the result of successful AR process and produces cm-level positioning with respect to a known base station transfer. The most precise double difference combination is the L1 fixed solution for a particular baseline. However, as the baseline length increases, other errors such as atmospheric biases, multipath and orbital errors become prominent.

Modern RTK GPS kits are all dual frequency instruments which perform both L1 and L2 measurements, although the most precise GPS baseline results achievable are in L1 only fixed solution. However, AR procedures are highly statistical and require a number of GPS epoch measurements to achieve successful initialization. Dual frequency receivers measure twice as much data therefore reduce the time for initialization. In real field situations however, when a surveyor experiences a total loss of lock with the satellite, it is desirable that the re-initialization be restored urgently.

Currently, the RTK technology is enhanced with active repeater stations which are specially designed to re-transmit the base station signals in the areas of poor reception. Such repeaters usually consist of a receiver and antenna, bass-pass filter, pre-amplifier, unidirectional amplifier and a transmitting antenna. These repeaters receive and transmit radio signals at the frequency of 1575.42 MHZ for penetration of bushes, hilly terrain [http://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf09969.htm[24]l].

4.2.5 Field Measurements

In testing the suitability of GPS in cadastral mapping, field tests were carried out at a site in Kwale County in Kenya (Fig.4.1). This site is an old sugar cane plantation where cadastral surveys were originally carried out in Cassini-Soldner projection in 1927 and 1938 to demarcate a 15,000 acres sugar cane farm for the Madhvani family (L.R.Nos 27742). This farm was popularly known as the Ramisi sugar factory which was established by the Madhvani family in 1922 at Ramisi in the South Coast of Kenya.

The factory went into liquidation in 1968 and was recently rehabilitated by a new company, the Kwale International Sugar Company Limited (KISCOL) which is currently in the process of replanting the old Ramisi farm with sugar cane through the drip irrigation system. KISCOL therefore required precise cadastral information to assist in the design of the modern farming system on a GIS based platform.

This necessitated provision of GPS control in differential rapid static mode to facilitate derivation of transformation parameters for the GPS coordinates and transformation of the Cassini coordinates into the 1960 Arc Datum UTM coordinates.

[24] This site was visited on 2nd April 2013

The existing national survey control points were investigated in the field and control points SKP 201.S.1 and SKP 200. S.10. These points were obtained as Trig Index Cards (Fig. 4.3 and 4.5) from the Department of Survey of Kenya. The points acted as base stations for densification of control points by use of GPS observations. The information on the two controls points and their associated trig index cards are presented.

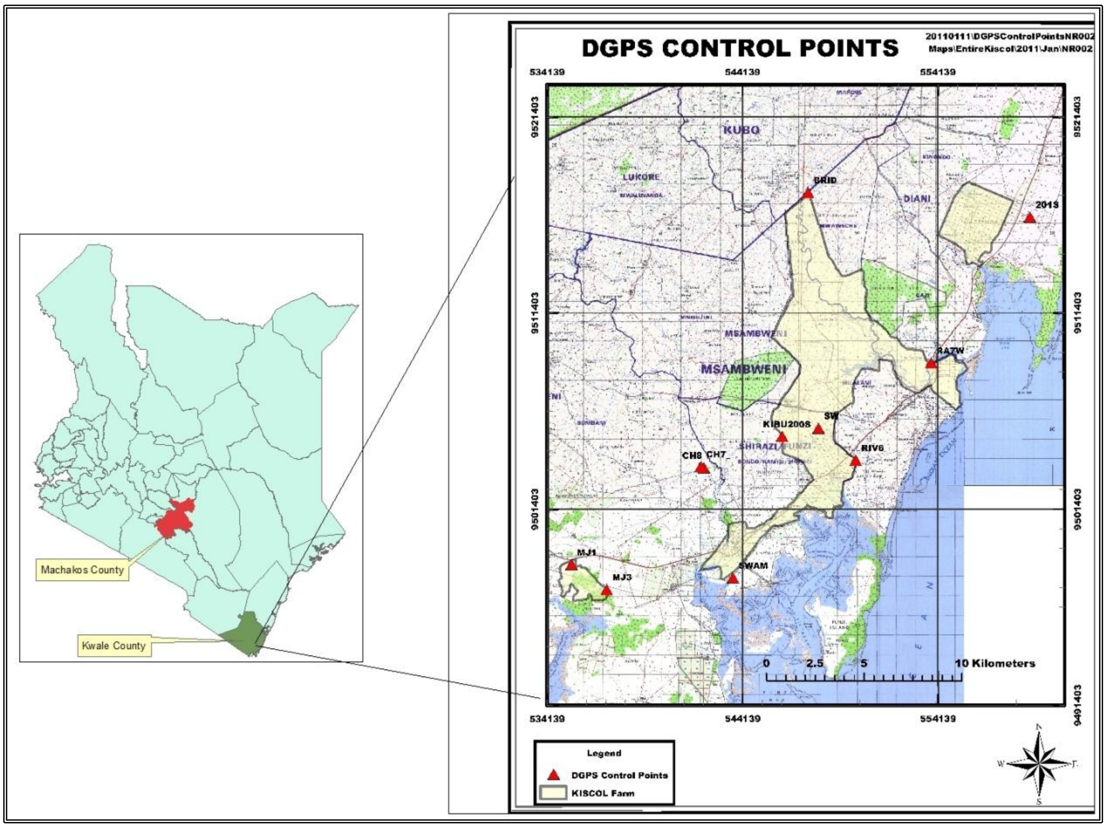
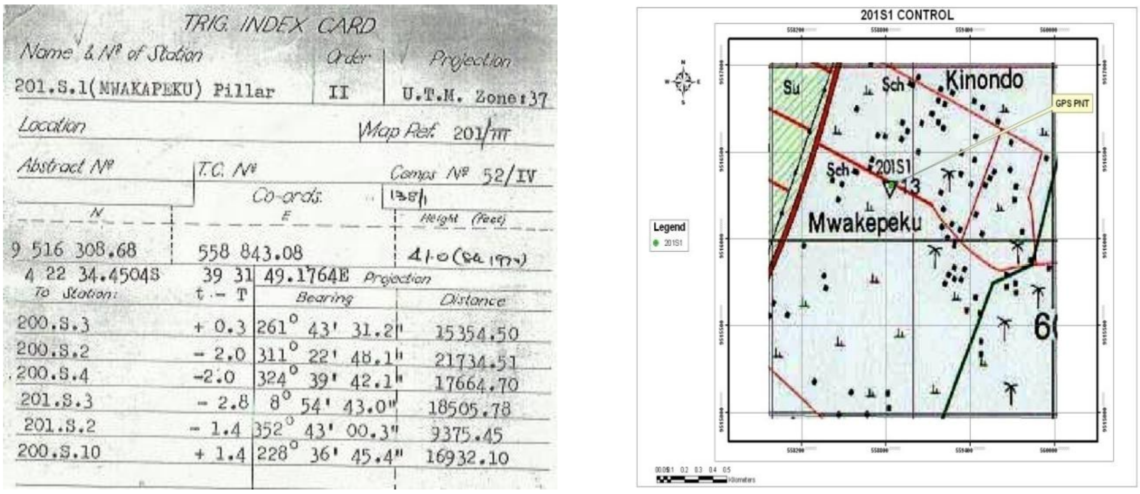


Fig 4.1 Map showing location of GPS Test site in Kwale County, Kenya (Source; Field work)

Fig 4.2 Leica GPS Receiver over control point SKP 201.S.1

Table 4.1 Coordinates of SKP 201.S.1 (MWAKAPEKU) (Source: Department of Survey, Nairobi)

Ellipsoid of Reference	Eastings(m)	Northings(m)	Comments
WGS 84 Coordinate System	558940.964	9516006.164	An International Ellipsoid
1960 Arc Datum Coordinates	558843.080	9516308.650	Clarke 1880 (Modified) Ellipsoid
Cassini Coordinates	+ 58768.03	-484052.70	Clarke 1858 Ellipsoid



TRIG. INDEX CARD

Name & Nº of Station	Order	Projection
201.S.1(MWAKAPEKU) Pillar	II	U.T.M. Zone:37

Location | Map Ref. 201/III

Abstract Nº | T.C. Nº | Comps Nº 52/IV | 1381

Co-ords.

N	E	Height (Feet)
9 516 308.68	558 843.08	41.0 (SK 1974)
4 22 34.4504S	39 31 49.1764E	Projection

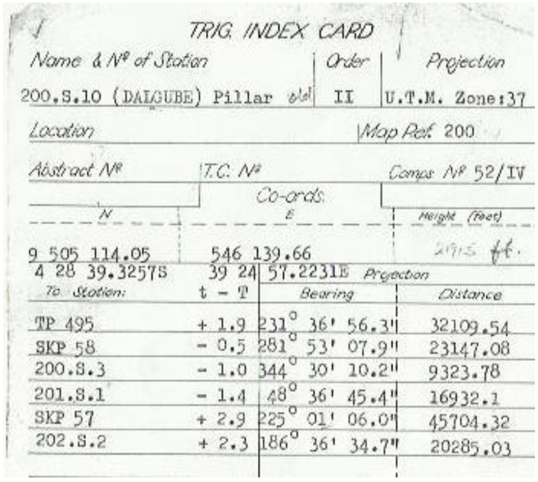
To Station:	t - T	Bearing	Distance
200.S.3	+ 0.3	261° 43' 31.2"	15354.50
200.S.2	- 2.0	311° 22' 48.1"	21734.51
200.S.4	-2.0	324° 39' 42.1"	17664.70
201.S.3	- 2.8	8° 54' 43.0"	18505.78
201.S.2	- 1.4	352° 43' 00.3"	9375.45
200.S.10	+ 1.4	228° 36' 45.4"	16932.10

Fig 4.3 SKP 201.S.1 and GPS Point (Mwakapeku)

Fig 4.4 Leica GPS Satellite Receiver at control point SKP 200.S.10

Table 4.2 Coordinates of 200.S.10 (Source: Department of Survey, Nairobi)

Ellipsoid of Reference	Eastings	Northings	Comments
WGS 84 Coordinates:	546241.791	9504843.033	International Ellipsoid
1960 Arc Datum Coordinates	546139.660	9505114.050	Clark 1880 (Modified) Ellipsoid
Cassini Coordinates:	+ 58768.03	-484052.70	Clark 1858 Ellipsoid



TRIG INDEX CARD

Name & Nº of Station | Order | Projection

200.S.10 (DALGUBE) Pillar old | II | U.T.M. Zone:37

Location | Map Ref. 200

Abstract Nº | T.C. Nº | Comps Nº 52/IV

Co-ords

N	E	Height (feet)
9 505 114.05	546 139.66	2915 ft.
4 28 39.3257S	39 24 57.2231E	Projection

To Station:	t - T	Bearing	Distance
TP 495	+ 1.9	231° 36' 56.3"	32109.54
SKP 58	- 0.5	281° 53' 07.9"	23147.08
200.S.3	- 1.0	344° 30' 10.2"	9323.78
201.S.1	- 1.4	48° 36' 45.4"	16932.1
SKP 57	+ 2.9	225° 01' 06.0"	45704.32
202.S.2	+ 2.3	186° 36' 34.7"	20285.03

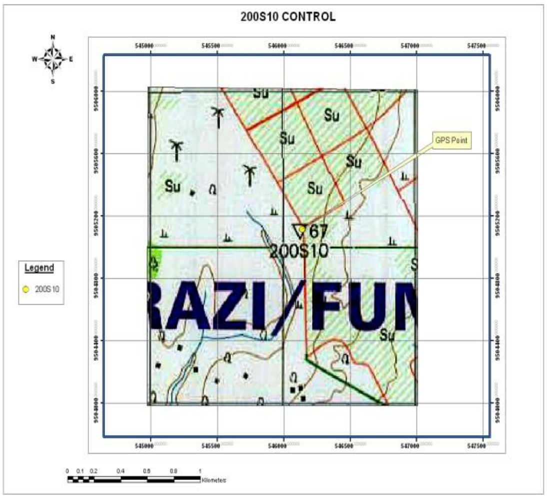


Fig 4.5 SKP 200.S.10 and GPS Point (DALGUBE)

Geodetic GPS observations were made with the two basic control points at SKP 201.S.1 and SKP 200.S.10 forming a baseline between them for making further observations. The basic controls were fixed in three dimensions coordinate system (X, Y, Z) by geodetic GPS in differential mode. The equipment was Leica5300 with 3SR399 built-in Antennas and CR333 GPS for taking the readings.

The field GPS data acquisition was done by Static Rapid Positioning that conventionally besides other methods provides the highest accuracy achievable and requires the longest observation times. A least squares method was used to adjust the observations. The two GPS stations were used as reference stations for derivation of transformation into the UTM system via vector computations. This method was adapted due to insufficient datum points available with adjustments made at the computation stage.

The GPS values (coordinates) were measured between the two datum points 201.S.1 and 200.S.10 giving a vector (distance and bearing) on the WGS 84 ellipsoid. From the local values given, i.e. Clarke 1880 (modified), it determines the vector say (V_L). The small angular deviations between the local vector V_L and V_{WGS} are also determined. These two corrections are then applied to all the radiating rays from either of the datum stations (Fig.4.6). The distortion-free transformation from one datum to another uses the Helmert Seven Parameter Transformation Formula which can be presented as follows.

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix}^B = \begin{bmatrix} c_x \\ c_y \\ c_z \end{bmatrix} + (1 + s \times 10^{-6}) \cdot \begin{bmatrix} 1 & -r_z & r_y \\ r_z & 1 & -r_x \\ -r_y & r_x & 1 \end{bmatrix} \cdot \begin{bmatrix} X \\ Y \\ Z \end{bmatrix}^A$$

Due to lack of enough datum points, the above method could not be used to derive the transformation parameters for the area. Therefore a combination of constraining baselines and height component to suit the local conditions plus scaling was used, by a combination of software. The actual baselines were computed using the vendor supplied software, and then exported into another. The result was then used to clean up the final values using the compound values. Finally the baselines were scaled using a priori information between the pillars, and the resultant vectors used to derive the final 3D values for the new points.

The final coordinates were then determined from the differences in the Northings and Eastings as given in Table 5.2 (in chapter Five). Their corresponding Orthometric heights are also given alongside plan coordinates. The GPS coordinates in Table 5.2 were plotted on mosaicked topographical of the area (Fig.5.2 in chapter Five). The results presented include UTM coordinates in the 1960 Arc Datum.

KISCOL required the coordinates of the Nucleus Estate in the UTM coordinate system in order to design a GIS based irrigation system. Some of the boundary points that were picked during the GPS were used to derive four parameters values for transforming the Cassini coordinates to the UTM system. These transformations were derived with MATLAB software. The parameters were then used to re-compute the whole nucleus estate in UTM as a base of registration of other thematic information. The UTM based Nucleus map is presented in Figure. 5.2 (in chapter Five).

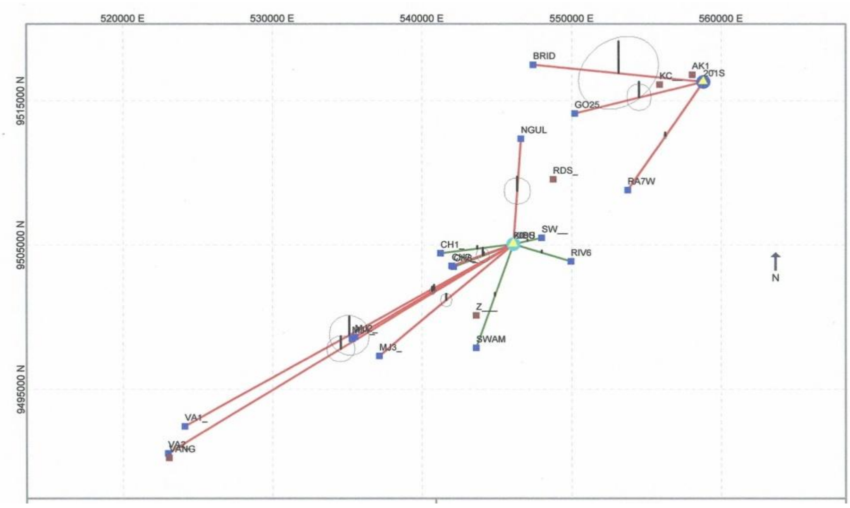


Fig. 4.6 GPS Vector Derivations for Positioning in the study area

(Source: Field work)

4.2.6 Measurements of General Boundaries.

Apart from surveying the Nucleus estate as precise cadastre, KISCOL also required the mapping of general boundary land parcels that had been purchased from the local land owners in the area. The general boundary system in Kenya refers to property boundaries that were demarcated by physical features at the time of land adjudication but without mathematical values. These boundaries were registered under the Registered Land Act (RLA) Cap 300 of 1963 while the precise cadastres are registered under the Registration of Titles Act Cap 281 of 1919.

The RLA, under sections 21 and 22 provide for the fixation of boundaries at the request of the client. The derived WGS-1960 Arc Datum transformation parameters were used to resurvey several general parcels into the UTM mathematical system. The write-up below presents application of GPS in the re-survey of general boundaries at Bumbani area (Fig. 5.1 in chapter Five).

The land parcel at Bumbani consisted of three units of land registered under the general boundary system. The general boundary system is derived from adjudication survey without mathematical coordinates. The properties are therefore usually expected to be represented by physically demarcated features such as fences, rivers, walls, hedges or even a coast line. In the study area, these plots were not demarcated with any physical features this makes it difficult to establish the boundaries on the ground.

According to the legal requirements of the Registered Lands Act (RLA, Cap 300), the Chief Land Registrar, Represented by the District Land Registrar on the ground, is supposed to show the position of the boundaries to the Land Surveyors before any boundary fixation can be effected. Unfortunately, the District Land Registrar is not a trained Surveyor and is not capable of showing the general boundary without the intervention of a Surveyor. It therefore becomes difficult for a Surveyor to clearly define the boundary of such parcels conclusively without a lot of intervention by the local administration.

In surveying the Bumbani property, great reliance was placed on an old cadastral plan FR 84/14 which formed one side of the boundaries. This plan was scanned and digitized in UTM coordinates. Two GPS control points CH1 and CH7 (Appendix 13) were established in the parcel during the GPS campaign. These coordinates were used to pick the river boundary, the outer perimeter of the parcel as shown by the Government Surveyor and the local community.

One side of the cadastral boundary of FR 84/14 (L.R.Nos. 9864) was adopted as the southern boundary of the plot. With these measurements, the boundaries of the parcel were established and fixed on the ground with Angle iron in Concrete (AIC). The diagram in Fig. 5.1 (in chapter Five) shows the general lay-out of the parcel together with the original parcels which were consolidated to create the Bumbani parcel. The survey data presented in Appendix 12 are for the traverses and the boundary beacons of the parcel. All the boundary coordinates were fixed directly in the UTM as the area had been surveyed as a general boundary. The results of the measurements are presented in chapter Five.

4.3 Remote Sensing Technology

4.3.1 Introduction

This section discusses the use of remote sensing technology in cadastral data acquisition in Kenya, particularly the land adjudication process. Land adjudication process was originally based on ground survey techniques such as plane table and chain surveys. Later, aerial photographs were incorporated in the exercise to assist in the computation of percentage cut and the reconciliation factor.

However, due to high demand for titles and political reasons, the use of rectified orthophoto was abandoned in favour of unrectified aerial photographs. Several authors, Ondulo [2010] Mwenda [2001], Njuki [2001], and Musyoka et al. [2010] have observed that the use of unrectified photos has caused a lot of distortions in the adjudicated boundaries. Furthermore, the acquisition of aerial photography is expensive as aircrafts have to be deployed every time such photographs are required.

Lemmens et al. [2009] have demonstrated that the use of high spatial satellite imagery may be a viable alternative to the aerial photos in land adjudication in Africa. The use of satellite imagery for cadastral application is however not new. Ondulo et al. [2010] have advocated the use of the technology in land adjudication. However, the spatial resolution has not been adequate for the very small land holdings in Africa; and it is only recently that imagery with high enough spatial resolution have been made available for cadastral surveying.

In an experiment in Ethiopia, cloud free Quickbird satellite imagery (at 60cm) resolution were used as the base for data collection. Extracts representing land size of 1km by 1km were plotted on a 1: 2,000 scale as a basis for data collection. This allowed for the identification and plotting of parcel boundaries from the smallest land units in the area. Georeferencing was conducted with hand-held GPS equipment with a nominal positional accuracy of 14m. A database containing administrative data on the parcels was created in Microsoft Excel and was exported and joined with the attribute table in a GIS environment.

4.3.2 The study Area

The study area for remote sensing test site is located in Machakos district, Kiandani Registration Section (Fig. 4.7). The study area was chosen for its diverse set of terrain features, data availability and proximity to Nairobi. The aerial photographs used were available at scales of 1:12 500 and 1:20 000; and the satellite imagery used was of good quality with a cloud cover of 3%. The Preliminary Index Diagrams (PIDs) were of continuous coverage and their Area List were available. However, the aerial photographs were not controlled hence the need for provision of photo controls.

Three types of data were integrated to provide the database used in this study; QuickBird orthoimage, aerial photographs and PIDs. The software available for use in the study were: ERDAS IMAGINE (Version 8.6 and 9.0), Arc View 3.2, Leica Geo-Office, Spectrum software, Ashtech Solutions 2.70, AutoCAD 2005, Statistical Package for the Social Sciences (SPSS) and Excel. The equipments included Contex Wide Format Scanner, Sokkia and Leica GPS receivers and a hand held GPS receiver.

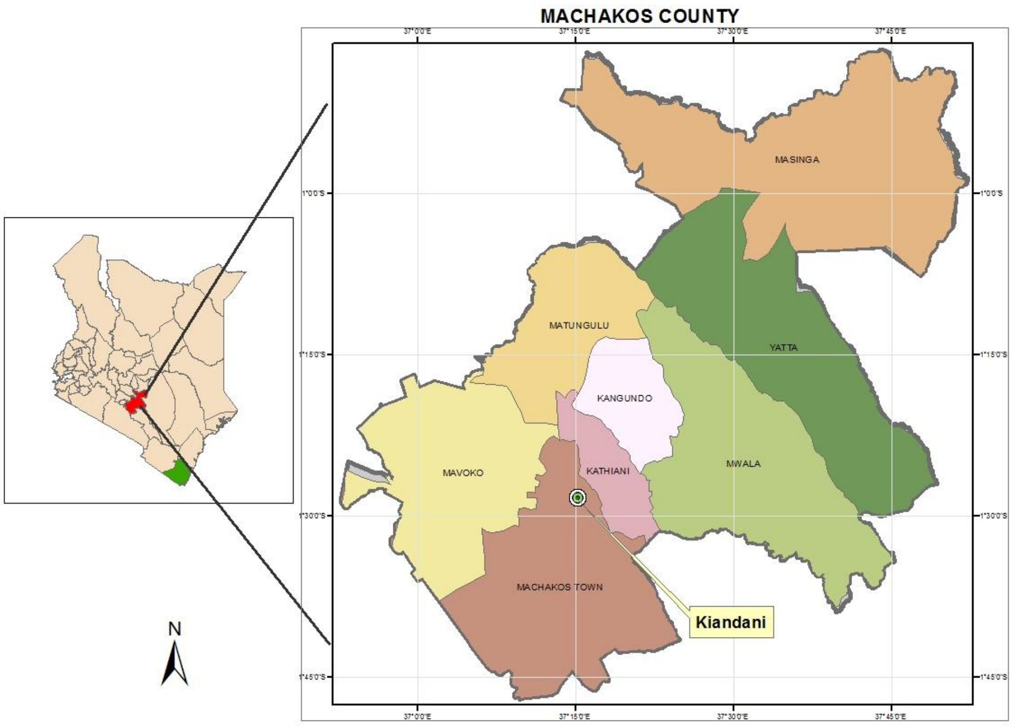


Fig 4.7 Location of the Satellite Test site in Machakos County, Kenya(Source: Own drawing)

This study designed a methodology to evaluate and analyze field data to determine the suitability of high spatial resolution satellite imagery for use in cadastral mapping. The overall research approach was mainly focused on the comparison of different datasets from which the parcel areas were extracted and evaluated by means of statistical analysis. The main assumption of the study was that the parcel areas obtained from satellite orthoimage and orthophoto are equal and that there is a difference in the case of PIDs versus orthoimage. These assumptions formed the basis for the hypothesis and the subsequent tests. The study sought for the prospects of integrating geospatial technologies in cadastral studies.

The use of aerial photography played a major role in cadastral mapping and presently high-resolution satellite data is providing the needed accuracy for cadastral level mapping at

1:4000 or better scale. QuickBird is currently the satellite imagery with the highest resolution for civilian uses (at 60cm) and thus was the choice for this study. The study uses parcel area information from orthophoto, which is assumed to represent the true ground area as the reference data and forms the basis for comparison.

To obtain the orthophoto, this research utilized archive photographs (scale of 1:12500) which were scanned, georeferenced using GPS coordinates, oriented (interior and exterior), and processed for digital elevation model extraction and Orthorectification. The GPS receivers were used in differential mode of surveying. This mode is recommended for photo scales in the range of 1/4000-1/50000. Parcel area information from orthophoto and orthoimage were obtained through on-screen digitization of parcel boundaries

While the orthophoto was produced for the study, the orthoimage was ready made from the supplier. The main reason for this was to cut down on the cost of production of PID from the orthoimage by bypassing the processes of orthorectification using GPS coordinates and image processing. Parcel area information was obtained in a similar manner as from orthophoto. In the case of PID parcel areas, the information was contained in the PID Area List provided by Survey of Kenya. Parcel classification with respect to acreage was conducted according to Labour Force Survey Report of Kenya (1998/9). According to this report, parcels have been classified into: (i) ClassA: (0.01 – 0.99 ha); (ii) ClassB: (1.00 – 2.99 ha); (iii) Class C: (3.00 – 4.99 ha); and (iii) ClassD: (≥5.00 ha). The results are presentenced and discussed in chapter Five.

4.4 GIS and Cadastral Modelling in Kenya

4.4.1 Introduction

The Geographic Information Systems (GIS) are computerized systems for managing data about spatially referenced objects. GIS differs from other types of information systems in that the systems manage huge quantities of data, require complex concepts to describe the geometry of objects and specify complex topological relationships between them [Stoimenov et al., 1998]. Additionally, GIS data are typically used by various groups of users with different views and needs.

Nowadays, GIS are considered as tools for general applications similar to Database Management systems. In this study, GIS was adopted as an integration tool for the spatial and non-spatial cadastral attributes. The main spatial attribute was the digitized cadastral map of the study area (Fig.**5.**41 in chapter Five) consisting of parcel land registry numbers, areas of the parcels and the orthophoto background. All the coordinates were converted from Cassini to UTM and the dataset was imported into the ArcGIS 9.3 platform. The conversion of coordinates from Cassini to the UTM was necessary because the GIS software used in the analysis only operates in the UTM.

4.4.2 Design of the Modern Cadastral Database Model

The design of the cadastral database Model was based on the three-level Architecture proposed by Connolly and Begg [1999:40] which consists of three sections; External, Conceptual/Logical, and Physical Modeling (Fig.4.8). This type of Architecture was adopted and recommended for database design (in 1975) by the American National Standards Institute (ANSI) Standards Planning and Requirements Committee (SPARC).

The three-level Architecture was adopted for the following reasons:

- each user has access to the same data but have different customized view of the data and any changes by the user does not affect other users
- users do not have to deal directly with the physical database storage system
- the Database Administrator (DBA) can be able to change the database storage structure without affecting the users views
- the internal structures of the database are not affected by changes in the physical aspects of the storage
- the DBA can change the global structure of the database without affecting any user.

External modeling represents the way users perceive data in the database while the internal modeling level is the way the Data Base Management System (DBMS) and the operating systems perceive data kept in the database. The external level consists of a number of different external views of the database

Each user has a view of the 'real world' represented in a form that is familiar for that user. The external view contains only those entities, attributes, and relationships in the 'real world' that the user is interested in. Other entities, attributes, or relationships which are not of interest to the viewer, may be represented in the database, but the user would not be aware of them. In this study, the external modeling was designed after carrying out user needs assessment in various organizations that interact with spatial data at the Ministry of Lands. These included departments in the Ministry of Lands, members of the Afya SACCO Cooperative Society (who own the land parcels in the study area), and members of the public and professionals who use land information frequently.

The Bogor Declaration [UN-FIG, 1996] recommended that in up-dating existing cadastral systems, there is a need to focus on user needs requirements and a re-formulation of strategic goals for land administration organizations. Users usually demand transparency, efficiency, speed, equitable access, data quality, interoperability, and a cost-effective system.

4.4.3 Conceptual Data Modeling

In the conceptual phase of the database development, all the datasets that need to be included in the data model are identified, together with the characteristics and relationships of the datasets. The aim of the conceptual model is to demarcate the part of the real world which is relevant for the specific application [Stoter, 2004:103]. In this study, the data model was implemented as a Multi-Valued Vector Map (MVVM) which allows different users to integrate information from different thematic applications [Bouloucos et al., 1992]. Each theme abstracts the real world into various geometric entities such as; points, lines and areas at the desired scale of abstraction. Through normalization procedures, the MVVM is translated into a fully normalized relational database structure.

Smith [1985] developed a new method for composing fully normalized relations without depending on the non-loss procedure. Smith’s method is a formal technique for deriving a set of normalised relations from a Functional Dependency Diagram (FDD). A FDD is a means of graphically modelling the dependencies within a collection of attributes. As part of this process, Smith defined two rules for deriving foreign keys; the target bubble rule and domain flag rule.

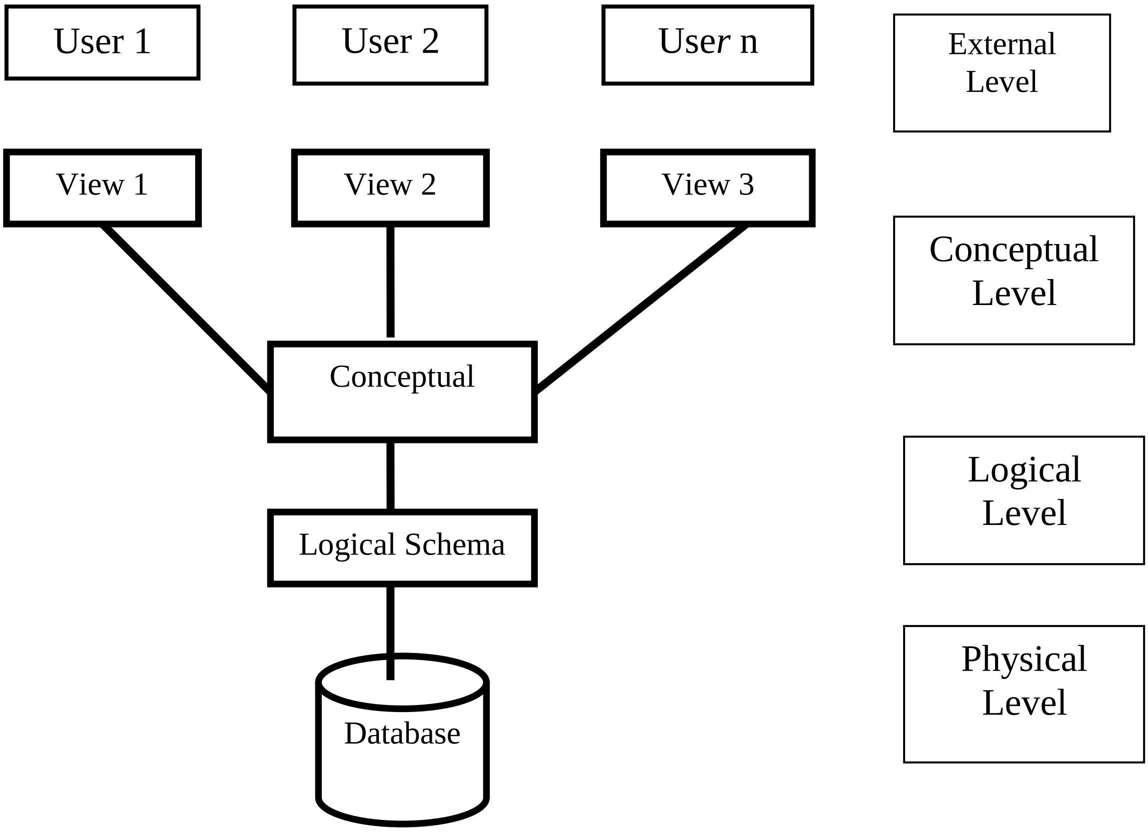


Fig 4.8 Three-Level Database Architecture (Connolly and Begg, 1999: 40)

The entire method of Smiths normalization is based on the concept of single and multi-valued dependencies. The method consists of the following steps in the order of listing; (i) the identification of the fields to be stored in the database; (ii) the listing of dependency statements in which the single and multiple valued relationships are expressed; (iii) the subsequent construction of the dependency diagrams; and (iv) the construction of a set of tables from the diagrams

The list of dependencies is created by carefully defining single valued and multi-valued dependencies between data fields. Each data field is assigned a single name and, if necessary, a definition is provided. Smith's normalization procedure was used in this study to design the relational database structure for cadastral system in the study area. The dependency diagrams developed and the statements are shown in Figures. 4.9 and 4.10.

The data types identified after the user needs assessment included; land parcels, survey plans, property ownership, and property value, encumbrances on property, utilities (e.g. water and electricity), registration, taxation, buildings and beacons. The dependency diagrams connecting these data types are presented in Figures 4.25 and 4.26.

4.4.4 Logical Modeling

This study adopted the hybrid system of object-relational model for the development of the cadastral database in a selected test site around the city of Nairobi (Fig. 4.28). The digitized cadastral plan was stored in the ArcGIS software as an object while all the non-spatial attributes of the land parcels were kept in a excel tables. All the table manipulations were implemented in the relational database while queries were implemented via the GinisNT software. Through this process, it was possible to upload the cadastral data from the ArcGIS and query the relational database through the RELATES.

The dependency diagrams constructed from the above dependency statements are shown below in Figures 4.9 and 4.10. Each data type is represented in an ellipse (or double ellipses to facilitate the representation of links) and the links between them are numbered according to the dependency statements from which the link is taken. Links may have single or double headed arrows depending on whether the link represents single valued or multi-valued dependencies.

The double headed arrows may also be taken to represent relationships that rea1: M in both directions of the arrow (in the direction and against the direction). It can be seen for instance that an area entity represents many area features and many area features also have many identifiers. The single headed arrows may be seen to represent relations that are 1:1 in the direction of the arrow but M: 1 against the direction of the arrow.

This can be seen from the fact that an area feature belongs to one area class (1:1 relationship in the direction of the arrow) while one area feature class has many area features (1: M relationship against the direction of the arrow). Where no arrow heads are drawn, we have a 1:1 relationship. The domain flag triangles with numbers inside them are used to identify all entities with common domain and facilitate referential integrity rules at the implementation stage.

The diagram presented in Figure 4.9 shows the relationships between the survey plans (FRs), the survey Land Registry Number (LRs) and several fields that commonly occur in a survey database. In Kenya, an authenticated survey plan usually shows the following features for reference and ease of identification: coordinate type, name of the surveyor who carried out the survey, his registered Assistant and their signatures, registration date, authentication date and computations number. This way it is possible for the government to follow up on who did the survey, when was it done and when was the survey submitted for checking and authentication to the Director of Survey.

Normalized Tables

Eight fully Normalized tables were composed from the dependency diagrams shown in Figures 4.9 and 4.10. The Tables were named as; Ownership, Back Plans, Survey Mark, Surveyor, Deed Plan, PIN Number. Each Table shows the relevant attributes obtained from the dependency diagrams and selected data types.

Ownership Table

A land parcel identified by LR (string) can be owned by one or more persons identified by a personal id Pers_id (type numeric) having an identification type (id._type) which indicates the type of identification the owner has. In the Table, the Pers_id (the PIN No) acts as a switch between the national identification card and the passport. Also included are the names of the plot owners as last name (lname), first name (fname) and middle name (mname). Through these combinations of attributes, it is possible to represent both single and multiple ownership of the plots. The relational tables representing these combinations are shown below. Fully populated ownership tables are presented at Appendix 3 at the back of the thesis.

The PIN No Table is part of the ownership where the PERS-ID in both the National ID and Passport tables, the PERS_ID is selected as the PIN No of the owner of the plot. Fully populated National ID Tables are presented at Appendix 5

A survey plan has one or more background plans BACK-plan (type string and domain of LR) upon which the survey was passed. These plans are usually referred to as the abuttals.

When a new survey is submitted to the Director of Survey for checking, the first aspect of the survey to be checked (through plotting in pencil) is if the abuttals agree seamlessly with the new survey to avoid overlaps and under laps. If there are any overlaps or gaps, the survey is returned to the Surveyor for correction.

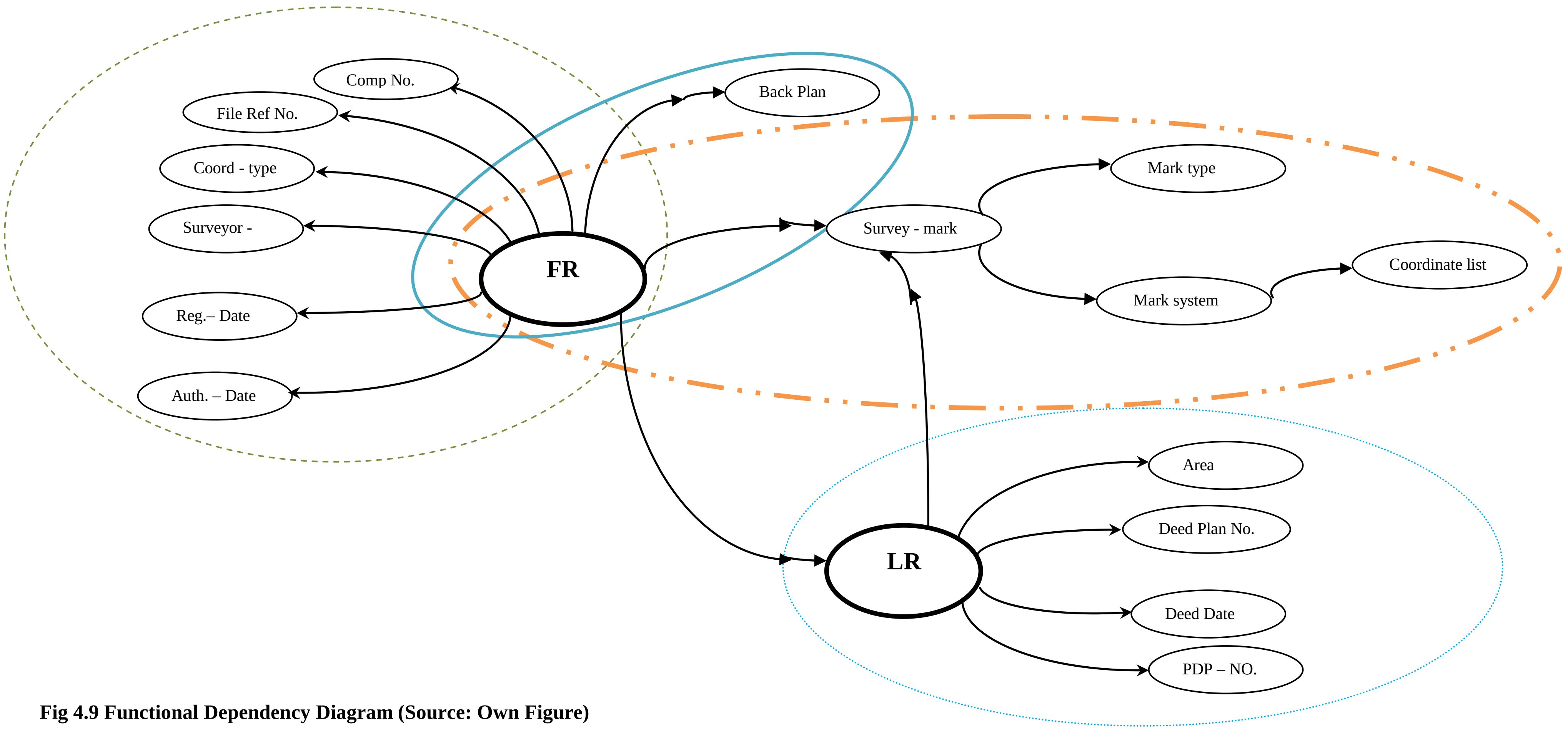


Fig 4.9 Functional Dependency Diagram (Source: Own Figure)

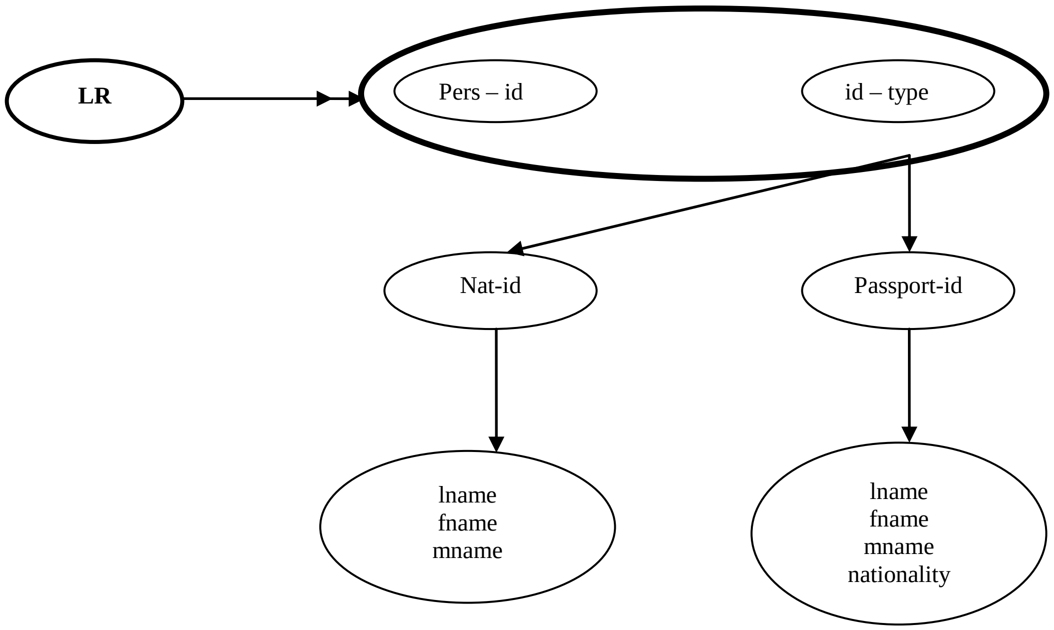


Fig 4.10 Dependency Diagrams showing property ownership (Source: Own Figure)

Table 4.3 Parcels Ownership

<u>LR</u>	PERS_ID	ID_TYPE

Nat ID

PERS_ID	ID_SW	NAT_ID	L_NAME	F_NAME	M_NAME

Passport

PERS_ID	ID_SW	PASSPORT	L_NAME	F_NAME	M_NAME

PIN No

LR No	PIN No

Back Plans Table

Table 4.4 Back Plans

FR	BACK-PLANS

Survey Mark Table

A survey plan has a coordinate list of all survey marks, each mark identified by SURV - mark (string) and every survey mark has a type identifier MARK – type (type numeric). Each survey mark has a unique set of coordinates in a given coordinate system MARK – SYS. A survey mark may therefore be indentified in one of more coordinate systems. The survey mark table uses the F/R No., the LR as the Primary Keys. Fully populated Survey Mark Table is shown in the Appendix 8.

Table 4.5 Survey Mark

FR	LR	SURV_MARK	MARK_TYPE	MARK_SYS

Surveyor Table

A survey plan has an identifier Folio Register Number (the FR) (type string) and has one or more parcels each having a unique parcel identifier Land Registry Number the LR (type string). The survey plan has the surveyor's identification number, surveyor_ id (type numeric), having a national identification card number Nat_id (numeric), Computations Number (numeric), the registration date REG-date (type date) of which the plan was registered by the Director of Surveys and authentication AUTH-date (type date) on which the survey was found acceptable and authenticated by the Director of Surveys. The plan also has a coordinate projection identifier COORD-TYPE (type numeric) which indicates the system upon which the survey was carried out. A fully populated Table is presented in Appendix 4.

Table 4.6 Surveyor

FR_No	SUR_ID	REG_DATE	AUTH_DATE	COOD_YTPE	COM-N	F_N	F-B

Deed Plans Tables

A parcel LR (String) appears in a unique survey plan FR, has area value AREA (type numeric) of the standard area unit, has a unique date on which the deed plan was issued identified by DEED date (type date). Each parcel has a unique Part Development Plan from which it was created given by PDP (type string) need to develop further with regard to planning details. These attributes are shown in the Deeds Table in 4.11. A fully populated Table is presented in Appendix 7.

Table 4.7 Deed Plans Table

<u>LR</u>	AREA	DP_NO	DP_DATE	PDP_NO

Although only eight Tables are presented, many more tables could be developed from the dependency diagrams in Figures 4.25 and 4.26. For example, a Table of title registration showing the Inland Registry Numbers of the titles could be developed and used to query registered plots against un-registered ones. At the time of developing this database, titles for the plots were not available.

Other Tables that could be developed include, Wayleaves and easements, mortgages and charges, and utilities (electricity and water supply in the houses), taxes (i.e. land rates, rents and stamp duty). These data were not available at the time of the research because most of them depend on registered titles. The only power line in the area is shown in the layout of the 628 plots. Information on easements was not available and it appears there may be none in the new estate.

The greatest achievement of Smith's normalization is that once the dependency diagrams are well developed, fully normalized tables are developed around the attributes from the dependency diagrams. In Figures 4.25 and for 4.26, the circles around the entities and their attributes automatically constitute a Normalized table under the Smith's normalization procedures.

4.4.5 Physical Level Modelling

At the stage of the Physical level design, the logical model is translated into hardware and software architecture. The database information at the internal level is hidden from the user and the design at this level is critical for the ultimate performance of various queries. The main objective of the internal level design is to enable the operations for manipulating the logical model in an efficient manner [Stoter, 2004:108]. In this study, the internal level model was implemented in a representative study site in Mavoko Municipality close to the City of Nairobi (Fig.5.14).

4.4.6 The study Site

The study site for this research was selected at Athi River in Mavoko Municipality selected for the following reasons; the area has a well laid out scheme of precise cadastral survey which has been checked and authenticated by the Director of Survey, the scheme has both spatial and non-spatial attributes which were found valuable for the development of the database, and the site is close to the City of Nairobi hence access for field visits and measurements are feasible.

Additional properties are that; the area consists of mixed land use and land cover types and encumbrances hence it provides a representative site for multi-purpose cadastral modeling, apart from cadastral plans, the area was recently mapped with rectified orthophoto which were available for the study, and the area has old control points in both Cassini-Soldner and UTM which were used to derive the transformation parameters; and (v) the clients were willing to participate in the development of the database

4.4.7 Transformation of Coordinates

The cadastral data used in this study were obtained in hard copy format from the Department of Surveys. The data consisted of six authenticated cadastral plans with coordinates in Cassini-Soldner projection. In total, there were six Folio/ Registration sheets containing a total of 628 plots. Forty plots from the scheme were chosen for the development of the cadastral database. These parcels were contained in plans covered by F/R Nos.339/32 and F/R 333/29. In order to acquire soft copy of the cadastral data, the plans were digitized with the ArcGIS software and co-registered with the orthophoto imagery.

Transformation equations were used to determine four transformation parameters (two translations in N and E directions, a uniform scale factor and one rotation angle) to convert the Cassini coordinates into the UTM (1960 Arc Datum) coordinates system. This was necessary to provide compatibility between the cadastral plan coordinates and the GIS system. Generally, GIS systems operate in the UTM while the cadastral plans in Kenya are on the Cassini system.

A network of four triangulation control points: SKP208 (LAMUIA), SKP216 (SAPUK), 148S4 (MARULAIS) and 149S3 (LUKENYA) with coordinates in both Cassini and UTM systems were used to derive the parameters. The datum coordinates of the stations selected are presented in Table 4.8.

Table 4.8 List of Datum Coordinates (Source: Survey of Kenya, Ruaraka)

Station Codes	**Names of Stations**	**1960 Arc Datum UTM Coordinates**		**Cassini-Soldner Coordinates**	
SKP 208	LAMUIA	9,843,205. 25	237,160. 30	-156,927.59	-40,380.73
SKP 216	OLDONYO SAPUK	9,874,247.920	306,011.96	-125,946. 38	+28,474. 84
148S4	MARULA	9,864,732.064	267,906.11	-135,431.75	-9,629.97
149S3	LUKENYA	9,837592.79	284,419.10	-162,578. 03	+6,855.62

The basic linear model for this transformation is given as:

E= b n + a e + ΔE

N=a n -b e + ΔN

In matrix form; $\begin{bmatrix} N \\ E \end{bmatrix} = \begin{bmatrix} a & -b \\ b & a \end{bmatrix} \begin{bmatrix} n \\ e \end{bmatrix} + \begin{bmatrix} \Delta\mathrm{N} \\ \Delta\mathrm{E} \end{bmatrix}$

Where; a= Scos (θ), b= S sin(θ)

S is the scale factor and θ represent the rotation angle that brings the two systems into parallelism.

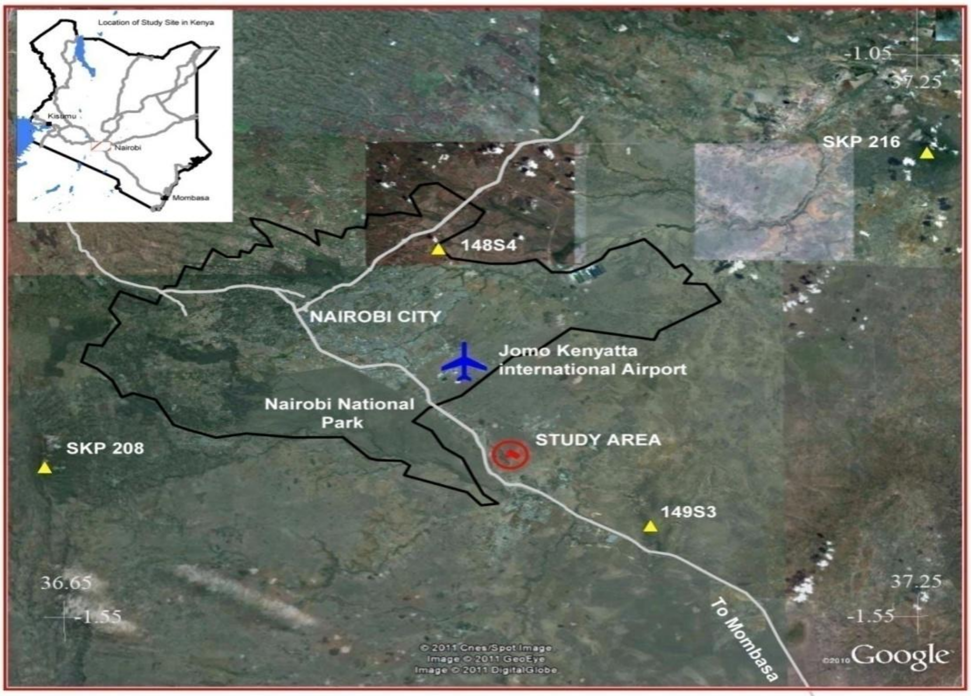


Fig 4.11 GIS Database Study Site (Source, National Museums of Kenya)

Where,

ΔN is the shift in Northern direction,

ΔE is the shift in Eastern direction,

N and E are the local UTM coordinates,

(n,e) are local Cassini coordinates,

The determined parameters given in Table 5.8 were then used to transform the Cassini coordinates into the local UTM (1960 Arc Datum) coordinates. The results of this transformation were used to derive the UTM coordinates of the parcels of the study are as presented in Figure 5.14 in Chapter Five.

CHAPTER FIVE

DATA FINDINGS AND ANALYSIS

5.1 Results of the Evaluation Processes

This chapter presents the discussion of results based on chapters two, three and four of this thesis. The discussion is divided into the three main areas; the results from the evaluation of the cadastral system, testing geospatial technologies and design of new cadastral model.

Table 5.1 below provides a summary of the valuation in terms of; the international indicators, internationally accepted good practices, the situation of the Kenyan cadastre, and the performance gap between the Kenyan cadastre and the internationally accepted practices. Data from the table were then used to develop a SWOT matrix showing internationally recognized benchmarks upon which any cadastral system can be evaluated, good international practices expected of a well functioning cadastral system, the situation of the Kenya cadastre, and the performance gaps.

Table 5.1 International Standards and Performance Gaps (Source: Field Evaluation)

International Requirements	Good International Practices	Situation of Kenya Cadastre	Performance Gap
Security of Cadastral Records	The system should be secure such that a land market operates effectively and efficiently. Financial institutions should be willing to mortgage land quickly. There should be certainty of ownership and parcel identification. The system should be physically secure with arrangements in place for duplicate storage of records in case of disaster. There should be controls to ensure that unauthorized persons cannot damage or change information.	The Kenya cadastre is physically secure but lacks a back-up system. All the land records are kept at the department of Lands while the survey records are kept at Survey of Kenya.	Lack of backup system for emergency recovery. Lack of comprehensive computerization as most land records are held in analogue form.
Clarity and Simplicity	The system should be clear and simple to understand and to use. Complex forms, procedures, and regulations slows the system down and may discourage use of the system. Costs in the system should be minimized, access should be fair, and the system should be well maintained.	The Kenyan system is complicated by various Acts of parliament which govern land, bureaucratic system in almost all land transactions, disparate tenure and registration systems.	Lack of harmonized Acts of Parliament dealing with land, non-computerized land records, too much paper work, and lack of decentralized system.
Timeliness	The system should provide up-to-date information in a timely manner, and all parcels should be included in the system	The cadastral system in Kenya takes too long to update. All land parcels are not always included in the system due to slow up-dating procedures.	Lack of computerization, lack of efficient data transfer system, and lack of automation in data-up-

Accessibility	The system should be able to provide efficient and effective access to all users of land information. This should be within the constraints of cultural sensitivity, legal and privacy issues	The precise cadastre is highly centralized in Nairobi and is therefore not easily accessible to all citizens. The RLA system has been decentralized to the districts	Lack of decentralization of the precise cadastre, lack of computerization

Table 5.1 Continued			
Cost	The system should be low cost or operated in such a way that costs can be recovered fairly without unduly burdening the users	The precise cadastral system is expensive but the RLA system operated at the Districts is cheaper and faster comparatively	Lack of rationalization of the cost of precise cadastral operations.
Sustainability	There must be mechanisms in place to ensure that the system is maintained all the times. This includes procedures for completing the cadastre in a reasonable time frame and keeping information up-to-date.	In Kenya, sustainability is quite adequate as the cadastral tasks are finished in time and accurately. This is due to a well and long-term development in the training of land related professionals. The up-dating system is however wanting.	Lack of quick up-date of the cadastre. The adjudication work is and encumbered with many litigations and government bureaucracy.
Political Aspects	Political aspects are remarkable in the way a democratic government and a good cadastral system go hand in hand, and how a civilized life is based on the fact that people know who owns what.	The political system in Kenya supports capitalism and mixed market economy hence the value of the cadastral system in Kenya is highly cherished. Title Registration system adopted in 1919 also supports the notion of who owns what.	Inaccurate PIDs and RIMs in the rural areas. Dependence on Deeds registration system while Title Registration system has been in place since 1919.
Legal Aspects	The main function of a cadastral system is to protect rights that people have in land and property and the structure of cadastral Law is therefore important.	The Kenyan cadastre provides enough protection to property in the urban areas. However ethnic differences affect these rights in the rural areas particularly in areas which are politically volatile.	Lack of political will to provide security of tenure in politically volatile areas.
Organizational Aspects	It is important that a cadastre is managed in a methodical manner. In case of different government levels (National, Regional, Local), it is critical how they cooperate with each other, and how the professional interaction works between Lawyers and Surveyors. It is also important where the financial responsibility lies for the whole system	In Kenya, the cadastre is managed in Nairobi and in the Districts. The cooperation between the different government levels is also amicable. The interaction between Surveyors and Lawyers is adequate. All the Finances are provided by the government.	There is lack of property register as land data is with the Commissioner of Lands while survey data are with the Director of Survey. Some operations could be privatized and Surveyors need to play a

Financial Aspects	The influence of who finances the system is crucial and so are the costs and fees involved in the process to register and transfer property rights	The government provides most of the funds to run the system. Processing funds are paid by the clients.	Lack of private sector participation in the running of the cadastral system in Kenya
Technology	The organization and functions of cadastre nowadays depends on the introduction of modern information and communication technology, and how much the customers are taken into consideration in this process	Introduction of modern ICT is slow and inadequate. Minimal digitization of spatial data has been initiated under the e-government policy.	Slow adaptation of modern ICT technology, no cadastral modeling and there is no customer participation in the process.
Land Policy Principles	Availability of National Land Policy which takes into account: responsibilities of the various land related activities such as land management, land reform, land registration, land administration, recognition of growing complexity rights, restrictions and responsibilities in relation to land, cost recovery of governments services	Kenya has not had a National Land Policy and depends on different Acts of Parliament to govern land. New Land Policy has been passed by Parliament and Sessional Paper prepared for implementation	A comprehensive land policy now in position for the first time in Kenya. Lack of a comprehensive cadastral reform to address international standards.
Land Tenure Principles	Formal recognition of appropriate land principles, recognition of indigenous and informal tenures, and appropriate response to circumstances of tenure.	The Land Tenure system in Kenya does not recognize and document indigenous land rights, and informal tenure systems. Also the government has not responded appropriately to special tenure issues in politically volatile areas.	Lack of recognition of indigenous and informal tenure. Lack of government guarantee of security of tenure in politically volatile areas.
Spatial Data Infrastructure Principles (SDI)	Recognize the role of SDI in supporting land administration, development of infrastructure or business systems and the role of land parcel layer in the SDI.	Currently Kenya does not have a functioning Spatial Data Infrastructure. The SDI committee has been formed and progressing towards launching the SDI soon	Lack of SDI and all the related benefits.
Human Resource Development	There should be sustainable long-term capacity of educated and trained personnel to operate the system in both the public and private sectors.	Capacity building has been built slowly since 1964 and today Kenya has highly trained personnel in various aspects of the cadastre. Higher levels of training at PhD level still required in almost all areas.	Inadequate training at higher PhD levels. Also more Licensed surveyors are required to sustain the private sector.
Sustainable Development	Land issues and land information play crucial role in the concept of sustainable development, which is the basic aim of global action plans such as Agenda 21. Sustainable Development relies on three main pillars of economic, soil and environmental concepts.	The Kenyan cadastre is traditional fiscal cadastre set up mainly for tax collection and has not embraced sustainable development principles.	Lack of observation of sustainable development principles.
Holistic Approach to Land Issues	Land issues are better dealt with when there is a political agreement for a common responsibility to land or an appointed land board or council that has the overall responsibility for the management of land.	In Kenya, land issues are managed by the Commissioner of Lands on behalf of the President of the Republic of Kenya. Currently, there is no board or council charged with the management of land.	Lack of one organization responsible for administration of all land issues in Kenya. Currently being constituted. National Land Commission being formed after passage of new Constitution

Inclusion of all rights, Restrictions, and Responsibilities	With increasing pressure on land, there is a trend that public authorities impose more and more restrictions and responsibilities on land, which are being integrated into the cadastre. Land owners and other participants need to know about all factors affecting land and its market.	The cadastral system in Kenya is comprehensive and documents all factors affecting land and the market, except indigenous land rights and the informal tenure systems are not recognized. Also land rights in the Trust Lands are not registered.	Lack of recognition and documentation of the indigenous land rights and the informal land tenure system. Also land rights in the Trust lands are not documented and not registered.
Good Governance and Civic Participation	Good Governance principles require that decision-making on land issues require transparence and complete information and n informed civil society that participates effectively in land matters.	In Kenya, the civic organizations participate in land issues effectively and have been responsible for the development of the Draft Land Policy document. However, access to information at the land registry is controlled.	Lack of transparency in the content of the land register and heavy state control of land. Citizen participation in ensuring accurate content of Register is lacking
E-Government	The development of E-Government is about the use of information and communication technology to facilitate the processes of government and public administration, including land information.	Kenya Government has already embraced the concept of E-government in various sectors of the economy. Currently, land information is being digitized.	Digitization is progressing at a slow pace. So far there has been no land modeling for the development of multiple purpose cadastre and property register.
Data Integration	The ability to integrate data from different sources is a crucial aspect for cadastral systems. Cadastral systems need to be standardized, complete, comprehensive, trustworthy and regularly up-dated.	The Kenyan cadastre is not integrated as survey information is with the Director of Survey while land information is with the Commissioner of Lands. The system is not standardized and is not regularly up dated.	Lack of integration, standardization, and regular up-dating. Lack of comprehensive Land Information Management System (LIMS)
Importance of spatial Data Component	Standardization of spatial data require a good geodetic reference and a good cadastral model. The Government needs to be spatially enabled	Kenya cadastre is currently operated on several disjointed geodetic frames and there is no standard cadastral modeling process.	Lack of harmonized geodetic system and establishment of cadastral models for realization of the multi-purpose cadastre.

5.1.1 The Strengths of the System

Organization Structure

The results basically present the strengths and weaknesses of the cadastral system in Kenya. In terms of its strengths, the evaluation shows the following strengths; some aspects of the cadastre have been decentralized to the Districts. These are mainly the general boundary registration system which has been in operation since 1956. The evaluation also shows that Kenya cadastre has a long history since 1903 when it was established and Larsson [2000:61] observed that this cadastre has promoted a strong land market in Kenya.

Land Policy

The other strong areas of the Kenya cadastre are in policy formulation and human resource development. Since the promulgation of the Constitution of Kenya 2010 and production of the Sessional paper No. 3 of 2009, the government enacted several Acts governing land. These include; the Land Act No.6 of 2012, The National Land Commission Act No. 5 of 2012, the Land Registration Act No.3 of 2012, and the Environmental and Land Court Act No. 19 of 2011. All these Acts have a major impact on the operation of the future cadastral system in Kenya.

Adjudication Programmes

In terms of the adjudication programme, Kenya ranks among the first countries in Africa to initiate a mass registration of rural lands through the adjudication of land rights in the rural areas. This process has enabled millions of indigenous Kenyans to acquire title deeds in a short time. Myles et al. [2009] have indicated that by the end of the 2010/2011, 1934 adjudication sections and 8.55million hectares of land (comprising 2.03 million parcels) have been covered. Additionally, 338 ranches (comprising 3 million hectares of trust land) have been registered.

Settlement Schemes and Cooperative Farms

Records available at the Ministry indicates that so far, the Government has settled 305,890 families in 469 settlement schemes, covering some 1,325 hectares of land. Where the government was unable to purchase land for settlement in the White Highlands, Kenyans organized themselves into groups, formed companies or cooperatives, and bought land on a willing buyer willing seller basis. Initially, these farms were managed as single entities but due to political, social, and economic factors, the government decided to subdivide the farms into the individual shareholders. Under this programme, 2,700 cooperative farms covering an area of 2.2 million hectares have been subdivided resulting in the settlement or development by the respective proprietors.

Land Alienation

The Crown Lands Ordinance of 1902 and the Government Lands Act of 1915 made provisions for the allocation of public land within townships for the orderly development of residential, commercial and industrial uses, infrastructure, utilities, recreation, as well as for residential, commercial, industrial and other public purposes. Under these allocations, 250,000 plots have been allocated and surveyed and the owners have been issued with 4,475,870 title deeds since the inception of the cadastral system in Kenya in 1903 [MoL, 2008].

Mapping of the Exclusive Economic Zone

The Exclusive Economic Zone (EEZ) under the control of Kenya extends about 200 Nautical Miles into the Indian Ocean. The boundary of this EEZ has been delineated on the navy marine charts and gazetted by the Government via Kenya Gazette Notice No. 22 of 22nd July 2005 (Legal Notice No. 82 and Legislative Supplement No. 34). This proclamation was deposited with the United Nations Secretary General and is contained in United Nations Law of the Sea Bulletin No. 61. It contains exclusively, an illustrative map of Kenya (SK 90 Edition 4) and two lists of geographical coordinates of points specifying the straight baselines from which the breath of the territorial sea measured, and the outer limits of the EEZ [GoK, 2009].

Development of a Modern Geodetic Reference Frame

The government is currently in the process of establishing 25 zero order and 75 first order Continuously Operating Reference Stations (CORS) to achieve the following operations; support the development of a modern geodetic network in Kenya, enhance cadastral mapping in the country, and promote the development of a computer-based cadastral data processing system.

5.1.2 The Weaknesses of the System

The Organizational Structure

The organizational structure of the cadastral system is highly centralized, complex and exceedingly bureaucratic. It is not accessible to the poor and is hostile to users. it is based on a manual Land Information System which badly needs computerization, it does not involve stakeholders in decision making at community level, and it relies on a complex legal system which is often not well understood by the users.

The Land Tenure System

The current tenure system has several challenges which can be summarized as follows; in the rural areas, the subdivision process has created fragmentation of land into sub-economic units, there is general tenure insecurity due to the existence of overlapping land rights especially at the interface between rural and urban areas, the system has promoted high levels of poverty in the rural areas and landlessness due to lack of capacity to gain access to clearly defined, enforceable and transferable property rights, gross disparities in land ownership with regard to gender and minority groups, and inadequate provision of the essential infrastructure which inhibit sustainable development of rural areas.

In the urban centres, there is a high proliferation of the informal settlements where the inhabitants lack any form of security of tenure. Although the Government has recently embarked on mapping of the informal settlements through the KISP programme, there are still no modalities for registering land rights in these settlements. The system has not recognized indigenous and customary rights.

Digital Land Information

In Kenya, because land information is still kept in manual format, the system is not only inefficient in land data management but is also beset with inadequate storage space. This hampers quick cross-referencing of records and constraints the orderly and timely updates of databases in use. In this state, data and information are not easily accessible, and as a consequence, important decisions on land can be made on unreliable information.

The Cadastral Data Models

Kenya still lacks a modern cadastral model, a situation which has contributed to several problems in the land administration system. The current effort at creating digital a cadastre has not culminated in the development of comprehensive cadastral model as the parcel information contained therein are only spatial information in the traditional cadastre without attributes.

National Land Information System

The National Land Information System (NLIS) is a computer-based information system that enables the capture, management, and analysis of georeferenced land information data in order to produce spatial information for decision making in land administration and management. The Government considers that NLIS would facilitate efficient and effective delivery of land and management services as spelt out in Vision 2030, the Constitution and the Land Policy documents.

The Ministry of Lands is aware from the past and present insights that a GIS-based land information system is central to the modernization of the Ministry's functions. The persistent lack of NLIS is greatly affecting the performance of the Ministry of Lands in terms of service delivery, access and sharing of land information.

Land Parcel Boundaries

Kenya currently operates three boundary systems: the fixed boundary, the general boundary, and the fixed-general boundary. The fixed boundary system conforms to the requirements of the international benchmarks such as Cadastre 2014 model as it is geo-referenced onto a geodetic reference system. The general boundary on the other hand does not conform to these standards as it operates in the enclosure system[25], where boundaries are defined by physical features. The boundaries of occupational land rights in the informal settlements are not recorded in the formal cadastre.

Land Registration Systems

In Kenya the land registration system is en-cumbered by several issues; it still operates both deeds and title registration systems although the title registration system was enacted to replace the deeds systems, there are several registration laws operating at the same time, which are confusing to both the practitioner and the users, it is encumbered by a bureaucratic centralized administration process, it does not recognize the indigenous land rights and the informal land tenure, and it does not provide for continuous up-dates.

[25] Enclosure system refers to the land reform in Europe in the 1700s. The system consolidated the tiny feudal land units into larger and more productive plots [Ting, 2002**]**.

Slow Adoption of Modern Technology

Slow adoption of modern geospatial technologies in cadastre (GPS, Remote Sensing and GIS) is one other major weakness of the cadastral system in Kenya. While many countries have adopted modern methods of cadastral mapping, Kenya still relies traditional methods for cadastral survey. Geospatial data exchange and transmission are hampered by lack of modernization in the cadastral sector and spatial information is still exchanged in the analogue format. This scenario is not conducive to the implementation of the e-government and achievement of the objectives of Vision 2030.

Duplication of Land Information

The new vision of the cadastral system envisages a modern cadastral infrastructure which facilitates efficient land and property markets and supports seamless exchange of geospatial information across the globe. Lack of collaboration between various spatial information stakeholders across any country results into duplicated management of the land information and impedes the implementation of the objectives of a modern cadastre. Usually this problem arises when spatial information are collected and maintained by different government organizations. In Kenya, this situation is rampant in several Government Ministries where most of the spatial information is duplicated resulting in a lot of data redundancy and a waste of resources.

Low Cadastral Coverage

In Kenya, the cadastral system covers only the 20% high potential areas of the country while the rest of the 80% are held under the trust lands where the local county councils administer the land on behalf of the resident communities. As such, large majority of Kenyan population have been disenfranchised without their consent. There is therefore an urgent need for the government to fast-track the adjudication programme in the rest of the country in order to bring all land to onto the register.

Lack of 3D Cadastre

In Kenya, both the technical and legal aspects of 3D cadastre are lacking. The closest approach to this property definition is the Sectional Property Act No.21 of 1987. The problem however is that under the Sectional Property Act, footprints of the buildings are coordinated in 2D and the rest of the vertical units are coordinated based on the vertical projection, where the upper corners are assumed to be vertically aligned to those directly below them. This assumption is not always true as there are many instances where walls are not vertical and floors are not lying in the same horizontal plane. In these instances, the application of Sectional Properties as it is practised in Kenya today fails and the titles issued become unreliable.

Cadastral Processes

Practically, all the cadastral processes presented in chapter two are bureaucratic, cumbersome and duplicative. While the process support of provision of spatial data for development, majority of them are laborious and repetitive in many ways. Several of the steps can be omitted without loss of information. The Ministry of Lands in its strategic Plan (2008-2012) identified cadastral processes as one of the major impediments to quick service delivery.

The Ministry therefore set out to improve services by carrying out the following reforms; review and document current processes, procedures and practices, undertake benchmarking of the cadastre, re-design the processes and practices. However, up-to-date, these initiatives have not been achieved and the results of this study should be a major contributor towards the implementation of some of these initiatives.

5.2 Results of Geospatial technologies

5.2.1 The Global Positioning

The GPS measurements presented in chapter four confirmed that the technology can be used for the capture of cadastral data in Kenya. However, some observations have been made that militate against its optimal use; currently, there are neither official guidelines for its use nor are there calibration bases for the GPS technology in Kenya, majority of the old triangulation points which form the reference data for GPS operations have been destroyed in many parts of the country, the technology, in its current form cannot be used for heighting due to lack of accurate geoid models, and the geodetic network in Kenya is not uniform, hence derivation of transformation parameters is tedious and time-consuming.

Rizos and Kadir [1999] observed that the practice of cadastral surveying is regulated by legislation and one of the requirements is that distances measured are traceable to primary standards of measurement through calibration. Accordingly, the legal definition of traceability is that a GPS measurement is legally traceable if, it is carried out using the various calibration procedures as prescribed by a guideline; the survey has followed a recommended practice for field and office procedures. In Malaysia for example, GPS measurements are not acceptable unless the equipment are calibrated every three months by one of the methods; a Zero-Baseline Test, EDM Base-line Test or GPS Network Test. In Kenya, there are neither GPS survey guidelines nor calibration procedures. Consequently, GPS measurements are not officially validated despite the current rampant use of the technology in several mapping operations.

Although Roberts [2005] reports that RTK is usable at base lengths between 10-15km, in this study, it was observed that the double differencing approach only operates up to 4km after which the base station has to be moved. Other limitations observed in the RTK measurements are; lack of capacity of radio signal to penetrate dense vegetation, inability to transmit the radio waves through high voltage power lines, and the cable connecting the base station with the radio link is short and inhibits movement of the radio link to sites far from the base station. However, active repeater stations have improved field measurements with RTK as longer distances can now be accessed without necessarily moving the base station.

The results presented in Figure 5.2 are the UTM plot boundaries derived from differential measurements in the KISCOL project in Kwale County. These coordinates were used to prepare a boundary plan of the old Ramisi estate, and the resultant map coincided exactly with the old Cassini boundary. The transformation parameters for Cassini to UTM coordinates are presented in Table 5.3.

Additionally, the beacon re-establishment with RTK (GPS) after the transformed coordinates was achieved at 3cm; as required by the Survey Act. This proved that RTK GPS is suitable for cadastral survey in Kenya. However, the main problem with differential measurements is lack of survey monuments for derivation of transformation parameters, as most of the survey pillars that were constructed for triangulation observations have been destroyed.

Table5.2 Results of Differential GPS Observations in UTM (Source: Field work)

Site ID	Eastings	Northings	Orthometric Heights
KIBU	546139.660	9505114.050	66.904
SW	548022.756	9505538.377	11.023
RIV6	549924.725	9503900.763	1.171
201S	558843.080	9516308.65	12.3
RA7W	553779.160	9508852.821	2.657
BRID	547481.604	9517546.744	62.437
SWAM	543637.065	9497913.396	-11.156
MJ1_	535366.925	9498556.145	1.448
CH 7	541991.945	9503585.836	9.502
200S	546139.660	9505114.050	66.904
CH1	541291.513	9504436.164	14.619
VA1	524143.546	9492435.706	1.813
VA2	522999.906	9490581.852	1.407
MJ2	535530.551	9498676.126	1.463
MJ3	537177.184	9497311.214	-6.075
GO25	550201.308	9514135.172	50.726
RDS	548794.079	9509575.681	66.536
NGUL	546629.395	9512409.541	115.01
Z	543655.408	9500149.183	39.311
KC	555863.919	9516135.523	33.015
AK1	558071.874	9516823.281	29.491

Table 5.3 Transformation parameters for Cassini-UTM Projections

PARAMETER	VALUE
a	1.002248791
b	0.0007371372
ΔN	10001507.607
ΔE	500339.6901

5.2.2 GPS and Fixation of General Boundaries

In the study area, an attempt was made in fixing the general boundaries with GPS derived coordinates. This proved successful and adequate for the accepted accuracy of 1m in the rural areas. However, reliance on differential GPS measurements with several geodetic stations is expensive for an ordinary practising surveyor. The best option for the government is to establish an adequate geodetic network to support single-receiver rural cadastral surveying. It is gratifying to note that the Government of Kenya, through the Survey Department, is currently establishing 25 zero order and 75 first Continuously Operating Reference Stations (CORS) to support GPS surveys and data transmission.

This study therefore observes that the GPS system (particularly the RTK) would be most useful in the georeferencing of adjudication parcels and general boundaries in Kenya. The main draw-back in using GPS for general boundaries surveys is the lack of maintenance of the physical boundaries on the ground. The Registered Land Act, demands that boundaries to be fixed have to be shown by the Land Registrar, who himself is not a trained surveyor and hence lacks the capacity to identify and map general boundaries. Consequently, application of GPS technology is compromised even after the transformation parameters have been derived.

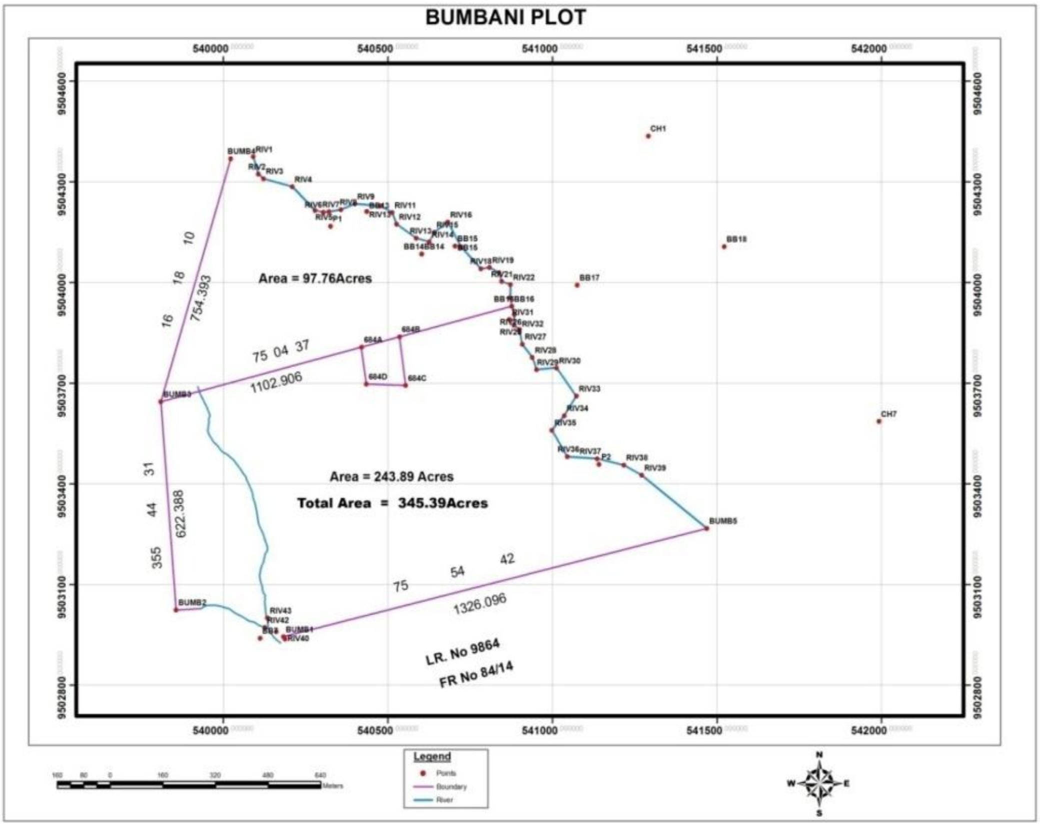


Fig 5.1 Layout of the Bumbani Parcels in Kwale County, Kenya (Source: Field work)

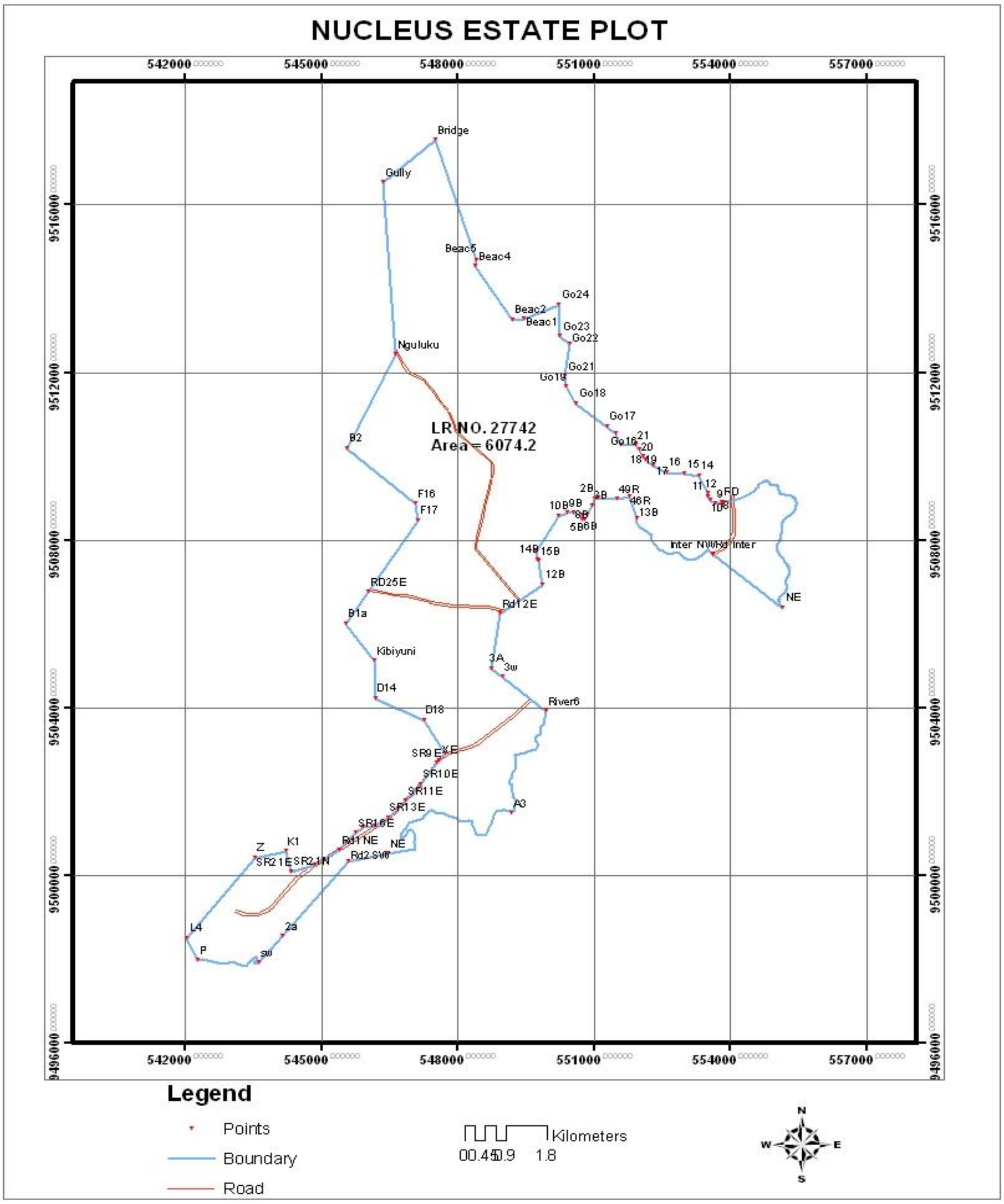


Fig 5.2 Layout of the Nucleus Estate in UTM Coordinates (Source: Field work)

5.3 Satellite Imagery Mapping

The study was carried out on rural properties bordering the urban area of Machakos Town. The land parcels considered in the study were easily identified on both the orthophoto and the satellite orthoimage. The parcel boundaries were characterized by trees, live enclosure or fences with presence of vegetation, roads or foot paths and water drainage with the presence of low altitude vegetation. Statistical analyses carried out on the parcels indicated that there was no significant difference between the orthorectified aerial photographs (orthophoto) and satellite image (orthoimage) for computing areas for land registration. On the other hand, there was significant difference between PID and orthophoto areas.

The evaluation was made by comparing the resulted digitized data from orthophoto image measurements – reference data – and the one from the orthoimage identification – extracted data and PID areas for each parcel encountered in the study area.

Table 5.4 Sampled Parcels in the study Area

KIANDANI REGISTRATION SECTION				
Parcel areas in hectares				
		[a]	[b]	[c]
No.	Plot No.	Satellite	Orthophoto	PID
1	2474	0.10	0.11	0.21
2	65	0.14	0.14	0.22
3	3870	0.19	0.18	0.22
4	225	0.21	0.22	0.20
5	2355	0.24	0.24	0.16
6	2401	0.30	0.31	0.30
7	2402	0.30	0.31	0.32
8	3869	0.32	0.33	0.30
9	3459	0.34	0.34	0.30
10	56	0.35	0.34	0.39
11	3846	0.35	0.35	0.35
12	64	0.35	0.36	0.30
13	172	0.44	0.44	0.47
14	2028	0.47	0.47	0.80
15	42	0.49	0.47	0.60
16	9	0.47	0.48	0.38
17	53	0.44	0.49	0.60
18	3001	0.49	0.50	0.51
19	3002	0.49	0.51	0.46
20	154	0.50	0.53	0.70

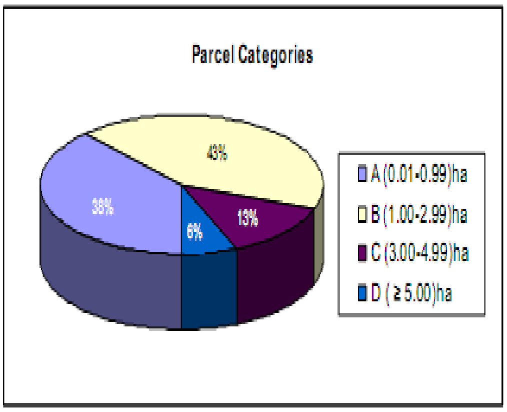


Fig 5.3 Distribution of parcels by percentages

Fig 5.4 Parcels Demarcated on Orthophoto

Fig 5.5 Parcels on Orthophoto and satellite imagery

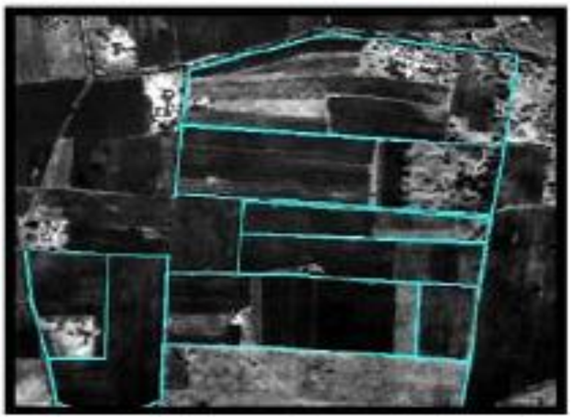


Table 5.5 Parcel size categories

Parcel Sizes				
Category	Freq.	% Var1.	% Var2.	% Var 3.
A (0.01-0.99) ha	48	16.2	16.6	2.6
B (1.00-2.99) ha	54	8.7	8.8	1.0
C (3.00-4.99) ha	16	6.6	6.6	0.3
D (≥5.00) ha	8	3.4	3.3	0.3

Var1 = Average parcel area difference between orthophoto & PID
Var2 = Average parcel area difference between Satellite & PID
Var3 = Average parcel area difference between orthophoto & Satellite

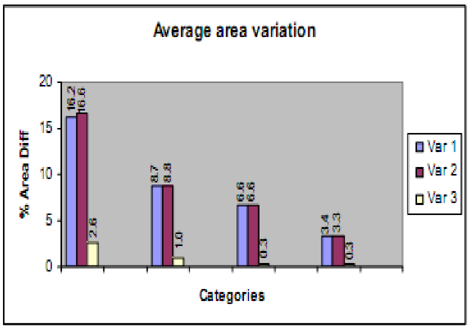


Fig 5.6 Area variations per category

Table 5.6 % area differences, orthophoto/ satellite

Range (%)	Frequency	Percent
≤10	125	99.2
11-20	1	0.8
Total	126	100

Range	Frequency	Percent
≤10	83	65.9
11-20	28	22.2
21-30	11	8.7
31-40	1	0.8
41-50	3	2.4
Total	126	100

Table 5.7 % area differences, orthophoto/ PID

The paired sample tests indicated that PID areas tend to be bigger as compared to the orthophoto areas while the opposite is true in the case of orthoimage. Bigger PID parcel areas were attributed to the variation of scale due to tilt. As the angle of tilt increases, the scale of photography becomes smaller. When scale gets smaller, the error quantity increases, consequently the bigger the distortion of parcel size and shape.

Majority of the parcels from the orthoimage had their area differences below 10%. A similar trend was repeated with the PID areas. In comparison to orthoimage areas, the PID areas had fewer parcels in the same range as shown in Tables 5.6 and 5.7. Some of the PID parcel areas were found to be in error of up to 50%. Ondulo [2010] indicated that an error up to ±2% in area and ±2m in position was acceptable to the majority of map users in Kenya. With this level of accuracy, 81% of parcel areas from the satellite orthoimage were found to be within this range.

Further analysis indicated that the smaller the parcels, the greater the error on their areas and vice versa. Figure 5.6 shows a summary of average area variation and the general trend taken by this variation on the parcel categories. It was also observed that land parcels with an elongated shape had larger errors in their areas as compared to the rest. Perhaps this is a good indicator as to the shape of parcels that should be adopted during land sub-division and adjudication exercises.

5.3.1 Rural Land Parcels

For large extension in gentle terrain, boundaries were easily identified in both the orthoimage and orthophoto. In this case, field borders are trees, live enclosure or fences with presence of vegetation, roads or foot paths and water drainage with the presence of low altitude vegetation. Variation between the reference data and the extracted one from orthoimage is very low (<3%) as observed in Table 5.7. There is a significant difference of result depending on the size of the property. Properties in category 'B', 'C' and 'D' presented an average area variation of 8.6%, 6.6% and 3.3% for PIDs respectively. However, the difference between parcel sizes is small (1.0%) and tends to zero as the parcels become bigger in the case of Orthoimages.

5.3.2 Analysis and Discussions

The logic behind the use of high-spatial resolution imagery over aerial photography is that, land titling can now be achieved much more rapidly than in the past by combining indigenous local knowledge of traditional boundaries with use of modern geospatial technologies. The introduction of high-resolution satellite imagery presents another opportunity for quick, cheap and accurate mapping and hence a quick solution to current land conflicts in Kenya today.

The operational method for this study can be suggested for the integration of remote sensing data and field data for the production of accurate registry index maps. Feature extraction from satellite imagery can be done through on-screen digitization with input of spatial information from field data. Thus the output can estimate the parcel areas more accurately in the form of a continuous parcel map with geographical extent, which will best compare with the actual parcel areas on the ground. This map can as well be referred to as registry index map due to their levels of accuracy.

Apart from the parcel boundaries, the satellite imagery would show extra details of land use and land cover patterns. These features would improve the quality of existing cadastral maps thus making them more suitable for land transaction, infrastructural mapping, land valuation and taxation.

The image used in this study presented some limitations, the presence of clouds and haze restricts the area of utility and the identification of parcel borders is more complex. However, more accurate results were obtained for medium size parcels and this was because the borders for category 'A' parcels were barely identifiable in the orthoimage and orthophoto, making the delimitation of boundaries almost impossible.

The variation of the parcel area between the orthophoto (reference data) and the one derived from the image interpretation (orthoimage) depends directly on the size. The variation of area was considered very low for larger parcels. However, smaller parcels in small agricultural areas and peri-urban properties presented a considerable variation of the area. This large variation of the areas can have significant consequences in land development planning and legal aspects. Therefore the use of satellite and orthophoto imagery in cadastral mapping in Kenya still needs to be supplemented with ground completion.

The use of current high spatial resolution satellite imagery in land adjudication in Kenya would eliminate area discrepancies and boundary conflicts associated with misrepresentation of spatial ground data by the land adjudication officers. Rionokal [2011] observed that in West Pokot County, land parcel boundaries are usually demarcated in advance by the local communities and are well marked on the ground by well-kept green fences. What the adjudication officers need to do is to map the boundaries accurately on a recently acquired aerial orthophoto or satellite imagery. This way the boundaries would be well represented and there would be no disputes or misrepresentation of areas of the land parcels.

What happens however is that the Land Adjudication officers use obsolete aerial photographs to demarcate parcel boundaries in the Arid and Semi Arid Lands (ASALS) where there is water deficit and parcel boundaries are not always air-visible. By the time such photos are used in land adjudication, majority of the boundaries have changed and the resultant RIMs are not representative of the ground situation. This results in artificial disputes and distorted parcel areas.

The ASAL population consists of nomadic pastoral communities who move from place to place in search of pasture and do not subscribe to the same land tenure systems as the sedentary communities. Lengoiboni [2011] has observed that pastoralists land rights are seasonal and spatiotemporal; which means that their adjudication requires deployment of more innovative approaches than hitherto applied.

5.4 Development of a Modern Cadastral Database

5.4.1 Distribution of Respondents

As indicated in chapter four, the main groups that were used in the external modelling included; departments in the Ministry of Lands, members of the Afya SACCO Society, professional Lawyers and Surveyors, and members of the public who use cadastral data from time to time. Each of these groups is discussed in terms of data acquisition, and general understanding of the subject matter.

The response to the respondents to questionnaires is presented in Fig. 5.7. In total, one hundred (100) questionnaires were administered but feedback was received from only 75 interviewees who were distributed as follows; Government officials 27%, Afya Sacco staff 27%, Members of the public 6%, and professionals 40%. The results are presented in Figure 4.16. The figure a hundred was chosen for the interview, because these were the respondents who were ready to take part in the interview

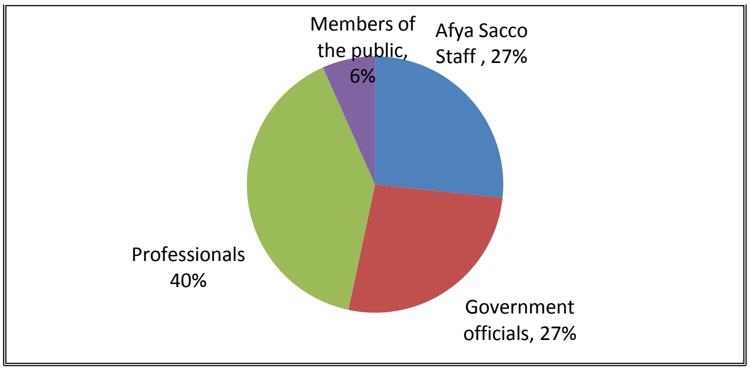


Fig 5.7 Distribution of the respondents (Source: Field Study, 2009)

In general, the results give a good response from both members of staff in the Ministry of Lands (at 27%) and members of the Afya SACCO at 27%. The best response was received from the professional group at 40% because of the frustrations they normally experience with land transaction services at the Ministry of Lands.

It was also observed that majority of the staff in the Ministry of Lands were uncomfortable with giving out written documents and referring the researcher to public in formation on the Notice Boards. Those who were willing to give information were not comfortable with their names included in the questionnaire document.

The implication of this behaviour is that the members of staff are afraid of reprisals from the seniors from divulging land related information. This is against the principles of Cadastral 2014 Model where it is indicated (in statement number one) that future cadastre will show the complete legal situation of land including public rights and restrictions.

The observation was that both Lawyers and Land Surveyors were open to discussion on the cadastral system. Lawyers were more concerned about the bureaucracy in the processing of cadastral documents and wished that the system could be re-organized to facilitate quick operations. The Lawyers interviewed gave useful information on land registration and conveyancing systems. Majority of Lawyers felt that all land operations should be established in one parastatal body rather than dealing with a myriad of institutions on land transactions.

Majority of the Surveyors were concerned about the time it takes to process cadastral data at the department of survey and recommended for automation of the entire system. Most of the Surveyors interviewed voluntarily availed information on land in both written and documented form.

Majority of the members of the Afya SACCO interviewed voluntarily gave out information on their rights on the land parcels. These included; names of owners, Identification card number, Tax PIN Number, land parcel areas and passport number where applicable. Most members were keen to have all the data presented in a geospatial database but the management were not ready to have the database developed immediately.

The members were keen to have data such as title deed and deed plan numbers to be included in the documentation. However, at the time of this survey, the title deed documents were not ready and were thus could not be included in the analysis. Other data which were considered were also not available for the research were; numbers for water and power metres for each parcel, rates and land rent payable annually on each property. As such, these data were not captured in the cadastral model.

Members of the public were interviewed as they came into the Ministry of Lands for services. The most common complaint from the public were; the delay in the processing of land documents including searches, the high cost of doing business at the Ministry of Lands, the amount of bureaucracy involved in the government land transactions, and that the cadastral system should be computerized and decentralized away from Nairobi.

5.4.2. Requirements of the Respondents

Out of the interviewed respondents, 22% indicated the needed to know about land ownership, 20% needed to know about their land title status, 35% were interested in the cadastral plans and matters related to their registration areas and 10% indicated interest in the mode of registration. Fig 5.8 shows the distribution in a pie chart.

These results indicate a low awareness of the problems besetting the cadastral system in Kenya. Majority of the members are interested in quick searches but do not understand that the high bureaucracy and duplication of services is delaying the services. The results indicate that there is a need for civic education to both service providers and those being served for the need of modernization of the system. As it is, members of the public indicate lack of awareness of the complexities of the operations of the cadastral system.

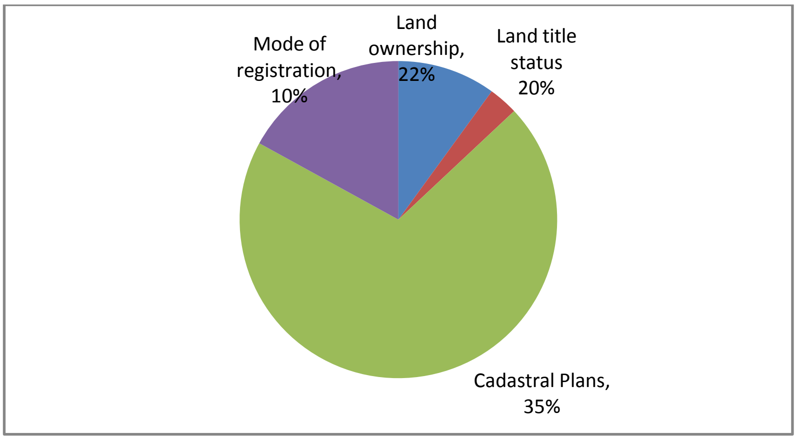


Fig 5.8 Requirements of the respondents (Source Field Study, 2009)

5.4.3 Preferences by Members of the Public

In this questionnaires, 30% of the public were interested in knowing the owner of the property, 55% wanted easy access to information during search while 10% were interested in any encumbrances that may affect the property, while 5% were not concerned (Fig. 5.9). The results re-affirmed the need for the development of automated land information system where members of the public can easily access the information. The development of a National Land Information System, in the form of a GIS Database would be able to solve this problem as different members of the public would be able to simultaneously access land information through the use-window.

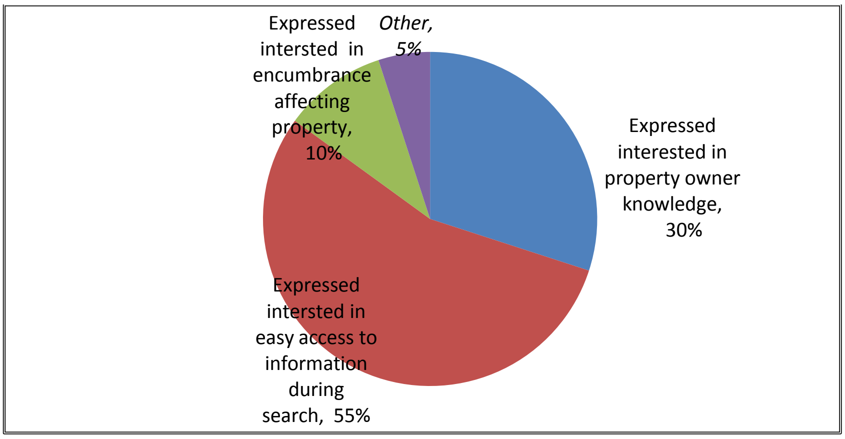


Fig 5.9 Preferences of Members of the Public (Source: Field Study, 2009)

5.4.4 Professional Groups Preferences

As for the professionals, 30% of the Land Surveyors and Valuers required survey plans, deed plans and details about titles. Majority of the Lawyers (about 40%) were concerned about the bureaucracy in the registration of titles. For the Afya SACCO members, 20% were concerned about the supply of facilities to the premises i.e. water, electricity and sewage disposal (Fig. 5.10).

These results present a picture of a frustrated professionals seeking for better services from the government as far as land transactions are concerned. Majority of the professionals interviewed felt there was a need for computerization and decentralization of services in order to speed up service delivery.

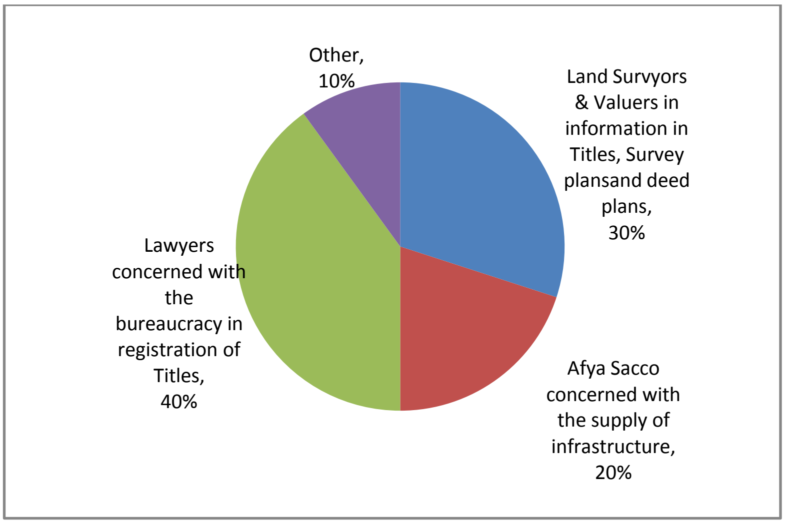


Fig 5.10 Professional Group Preferences (Source: Field Study, 2009)

5.4.5 Communication of Cadastral Information

In this category, 47% of the respondents indicated a major concern on the centralization of the RTA registration in Nairobi and recommended that these services should be decentralized to the Counties and Districts. 33% of the respondents addressed the role of GIS and LIMS in the cadastral administration in Kenya, and indicated that the two systems should be central in the implementation of the automated land information system. It was felt that the use of these technologies would improve data accessibility and provide a link between the spatial and non-spatial data. 13% of the respondents observed that due to the presence of the World Wide Web, cadastral information should be transferred via an on-line enabled distributed database system. The rest 7% of the members did not comment. Figure 5.11 shows the distribution in a pie chart.

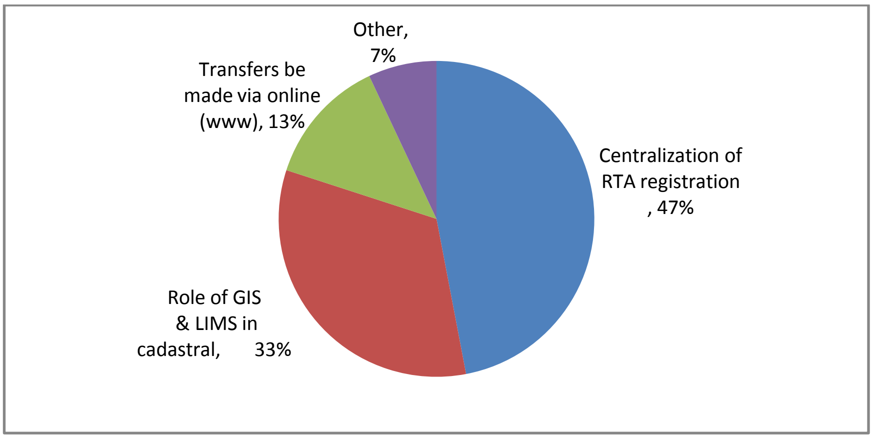


Fig 5.11 Communication of Cadastral Information (Source: Field Study, 2009)

5.4.6 Data to be included in the Database

In terms of data to be included in the database, 20% argued for building information and the property register while 20% of the respondents argued for telephone, e-mail and website numbers to be included in the database. 23% of the respondents needed other data such as Tax PIN Number, VAT Number and date of taxation. 10% required inclusion of land use, building details, type of soil and the nature of the land. 27% required the inclusion of the value of the property and services supplied to the properties. Figure 5.12 shows the distribution in a pie chart.

The information on value of properties came mainly from the Land Valuers and members of the public who needed to know the value of land for purchase purposes. Information on buildings came mainly from members of the Afya Sacco and members of the public who were interested in the land use of the plots they wanted to buy. Transmission of cadastral information through telephone, the Web and E-mail came from all respondents. Information on the PIN Number, VAT Number and status of taxation came from Lawyers who were involved in property transfers. Members of the public who are interested in the status of tax compliance for the plot owners were also concerned about the taxation information. Information on land use, soil type and nature of land came from Valuers.

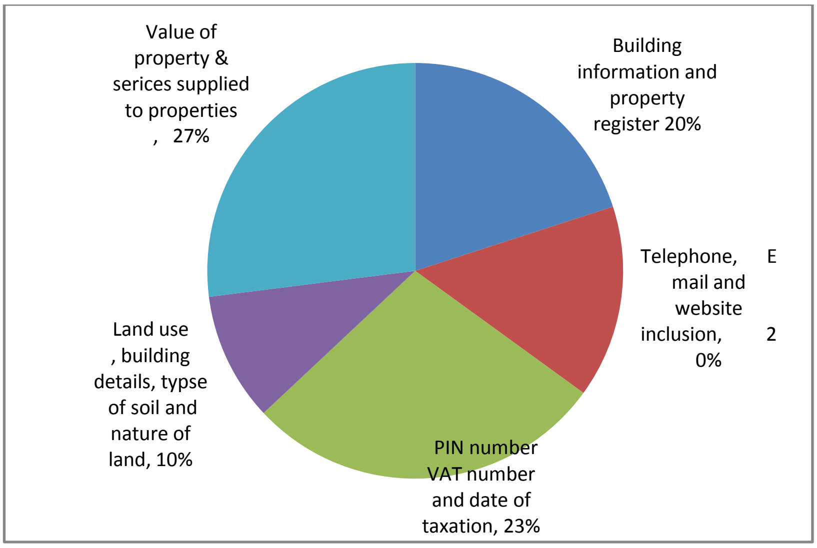


Fig 5.12 Data to be included in the Database (Source: Field Study, 2009)

5.4.7 Modern Management of the Cadastre

Most of the respondents were of the opinion that the cadastral system should be fully digitized. 60% concurred that there is an urgent need to develop modern cadastral databases for ease of management of the system. 30% of the respondents identified the district as the ideal unit for the decentralization of the cadastre. The Counties, divisions and locations had responses 10% as indicated in Figure 5.13 the pie chart. Most of the professionals however advised that the decentralization of the cadastral system should be carried out gradually starting with the new Counties and eventually settling at the Districts, Divisions and locations.

These respondents emphasis was on decentralization of services from Nairobi in order to improve services to the public. In Kenya, the registration of general boundaries under the Registered Land Act, Cap 300 of 1963 has already been decentralized to several Districts in the Republic. However, transactions involving precise cadastral surveys, title registration and all urban land transactions are still based in Nairobi.

This is a major area of concern which will have to be addressed in the devolved government system. At the moment, all RTA titles and checking of survey jobs are centralized in Nairobi, and it forces any member of the public to travel long distances and incur expenses for services in Nairobi. Part of the RTA registration has been decentralized to Mombasa for the Coastal plots, however, all the documents for registration are still prepared in Nairobi, and the Registry in Mombasa only performs the title registration aspect.

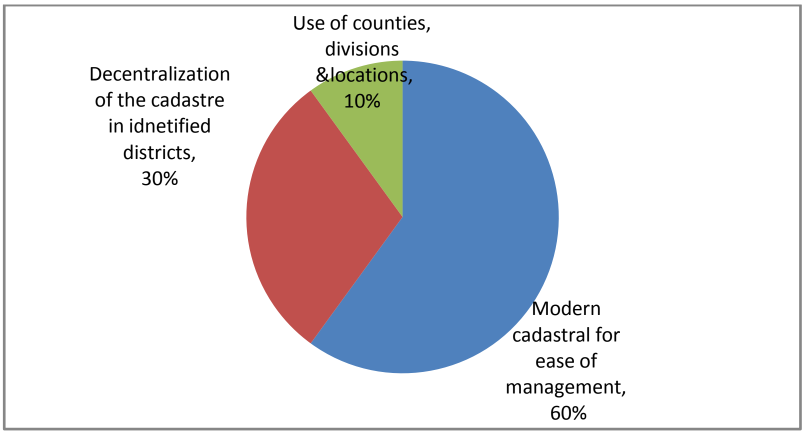


Fig 5.13 Management of Cadastral Data(Source: Field Study, 2009)

5.5 Conceptual and Logical Modelling

The design of the conceptual model for this study was based on three principles; adoption of the three-level architecture, the use of the Multi Valued Vector Maps (MVVN), and Smiths Normalization Procedure.

5.5.1 The Three-Level Architecture

The Three-level architecture separates each user view from the main database such that, users do not have direct access to the physical database. This way, the Database Administrator can change the database storage structures without affecting the user's views. For example, the external view contains only those entities, attributes, or relations which are not of interest to the other viewers. In this study, this was a desirable feature since the cadastral database developed would be expected to serve different people and organizations at the same time. For example, some clients may be viewing their tenure system while the Tax agencies are checking on the tax compliance of a particular client. These two operations can proceed at the same time in a database based on the three-level system without any conflict.

A cadastral database based on the Land Administration Domain Model (LADM) [Lemmen, 2012] is required to contain both legal and administrative object classes like persons, rights and the geographic description of real estate objects. This means that the different datasets are maintained by different organizations but all accessed through the distributed database system. The different organizations would be expected to maintain their own data and communicate to the database from time to time through standardized processes such as the Spatial Data Infrastructure.

5.5.2 The Multi Valued Vector Map

The use of the MVVN was found justifiable due to the following needs; it allows different users of the database to integrate information from different thematic applications, it allows each theme to abstract the real world situation into various geometric entities such as points, lines and areas at the desired scale of abstraction, it provides for nodes which can represent one or more point features, an arc, or a feature type, and it provides the basis for defining Functional and Multi-Valued Dependencies which do not create anomalies in the implementation of the database.

The use of the MVVN and the hybrid database model satisfied the fundamentals of database design which include; the structure criteria, performance criteria and programme development criteria. The structure criteria concern data structures such as data consistency, redundancy, flexibility and completeness. Performance criteria pertain to efficient use of data (i.e. data reliability, currency, storage and response times); programme development criteria concerns data access and the ease of developing application software.

5.5.3 Smiths Normalization Procedure

In this study, Smiths Normalization was used together with Functional Dependency Diagrams to create completely Normalized tables without resorting to the loss-less procedure of Cod [1970] and Date [1990]. This enabled automatic querying of multiple plot ownership which has not been possible under the normal Codes Normalization procedures. The FDD presented in Fig. 4.9 shows two important issues in database design and normalization of tables. By developing the entity relationships of the datasets in the FDD, the tables to be developed are automatically created. In the diagram the areas for creation of the tables are represented differently coloured ellipses. This is an important aspect of the conceptual and logical design as the design as the tables are automatically normalized.

In the same diagram, the cardinalities between various data sets are shown by arrows as required in Smith Normalization procedure. All 1: M relationships are represented with single arrows while 1:M or M:M relationships are represented with double arrows. These arrows automatically indicate the associations of attributes and help create fully Normalized tables before instantiation.

5.7 Physical Modelling

At this, stage the logical model is translated into the hardware and software architecture of the database. The design of the internal level modelling is critical to ensure a good performance of the query commands. It is also responsible for assigning storage areas for the different datasets in the database. In this study, the designed cadastral model was implemented in the Mavoko Municipality around the city of Nairobi. The process involved; populating the tables, transformation of coordinates, digitization of the cadastral plans, and registration with high resolution orthophoto imagery and querying the database.

5.7.1 Transformation of Coordinates

In order to develop a modern cadastral model, it was necessary to convert all coordinates from Cassini into the UTM system so as to have all the spatial data compatible with the GIS software systems. The results presented in Table 5.8 and indicate that; a four parameter transformation is adequate for derivation of the transformation parameters required for cadastral mapping. The map shown in Figure 5.14 is the result of the plots that were digitized from the transformed coordinates and saved as part of the spatial database. Some of the challenges noted in this process were that; it is difficult to obtain points with both Cassini and UTM coordinate systems as most of the old survey monuments have been destroyed, the records at the Survey Department are not kept up-to-date hence the reliability of the coordinates data is doubtful, and there are several cadastral coordinate systems in Kenya and selecting the right coordinates for transformation can be confusing.

Table 5.8 Derived Transformation Parameters

Parameter	Value	Accuracy	Units
S	1.0000169	±0.000002	-
θ	-0.000886	±0.000002	rad
ΔN	10,000,167.51	±0.35	m
ΔE	277,419.49	±0.35	m

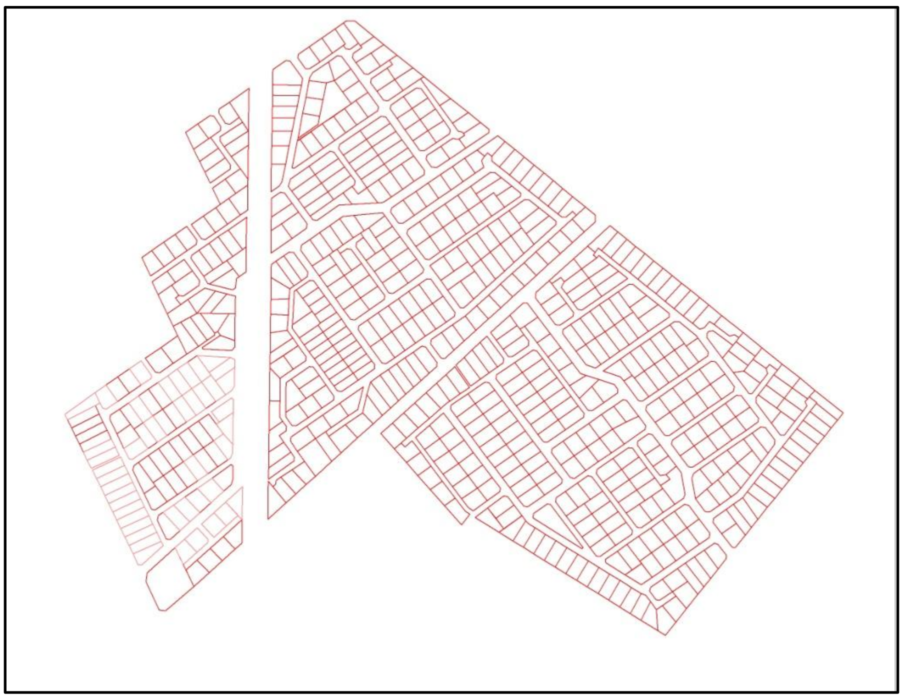


Fig. 5.14 Digitized cadastral map of Mavoko Site (Source: Field Work)

5.7.2 Acquisition of High Spatial Resolution Imagery

In order to show the land use patterns in the study area, high spatial resolution Orthophoto imagery were acquired from the Kenya National Bureau of Statistics (KNBS). These data had been acquired by the government for the Kenya Population and Housing Census exercise which took place between 24th and 30th August 2008 [GoK, 2010]. The results presented in Figure 5.15 show that the integration of this data with the digitized cadastral maps is essential for the determination of the land use pattern in the study area.

Fig 5.15 Cadastral map and the orthophoto imagery of the study area (Source: Lab work)

The challenges of acquiring such data in Kenya are; the data are generally acquired for specific purposes and are rarely accessible for database development, it is generally limited by scale, resolution, colour and /or date are expensive, and the registration with other spatial data is difficult because of the several coordinate challenges and lack of ready-made transformation values

It is therefore recommended that the acquisition of such data should be carried out regularly to support various development needs. In Kenya, there is a comprehensive catalogue of the old photogrammetric coverage for most parts of the country. However, digital Orthophoto coverage is limited and acquisitions are specific to projects. High spatial satellite imagery are available for most parts of the country but the prices are exorbitant. The Google Earth imagery have not been fully integrated in cadastral mapping but have the potential for future applications.

5.7.3 Composition of Normalized Tables

The entire method of Smith's normalization is based on the concept of single and multi-valued dependencies. The method consists of the following steps in the order of listing; the identification of the fields to be stored in the database, the listing of dependency statements in which the single and multiple valued relationships are expressed, the subsequent construction of the dependency diagrams, and the construction of a set of tables from the diagrams.

The beauty of Smith's Normalization process is that it would fully capture the cadastral system in Kenya. For example, the Object-Oriented method assumes that the cadastral system is purely parcel based. In Kenya, the entry point into the cadastral system is the Folio Registry Number (F/R. No); from which the researcher navigates into the parcels through the Land Registry Numbers. The Dependency Diagrams in Figures 4.9 and 4.10 (in chapter Four) clearly show the ease by which Smiths Method assists in the design of the relational schemers.

5.7.4 The Query Operations

The hybrid system is supported by a robust GinisNT and Mediator systems which ensure a smooth operation between the OODBMS and the RDBMS which are both contained in the GinisNT system. While the purely RDBMS relies on joins for query developments, the hybrid system uses relates to access information in both databases, which is particularly suitable where spatial data analyses are concerned. In this study, for example, the cadastral data are kept in the GIS database while all the attributes are in the excel tables (in the Appendix). Without adopting the hybrid system, it would have been difficult to query the spatial data as typical join operations tend to de-normalize the tables.

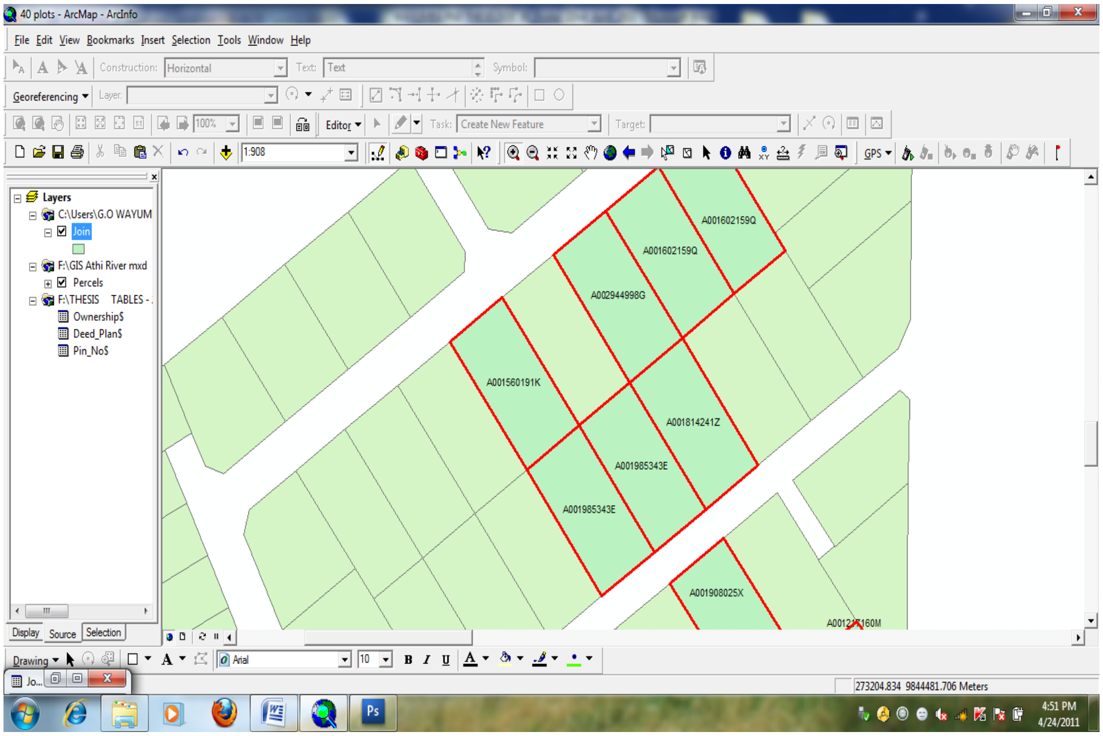
The queries were constructed via the SQL module in the ArcGIS system. Once the RELATES were established between the OODBMS and the RDBMS, queries were built using the SQL module within the ArcGIS environment. In this study, the queries such as LABELLING and SELECT were implemented on the cadastral plan via the GinisNT procedure explained above. For the M:1 relationships, a special computer programme was developed to select the parcels with multiple ownership (Tables 5.11and 5.16).

The process of labelling involves querying the computer to display certain labelling commands. The computer may, for example, be requested to label all the built-up plots in the study area. By using the label command, all the developed plots are labelled and the non-developed ones are left vacant. In this study, several labelling queries were implemented as shown below.

In Table 5.9 the Labelling query was used to show the PIN number of the plot owners onto the cadastral plan held in the GIS database. This was accomplished by the user requesting to be shown the PIN Number of the chosen parcels in the study area. This is a facility which would be useful to the Kenya Revenue Authority and the Local Authorities when they want to identify plot owners and track whether they have paid the requisite taxes; particularly land rent, land rates and stamp duty on transfer of plots.

PIN Number is important to the Kenya Revenue Authority (KRA) as it is associated with the taxation process. At the moment, the Commissioner of KRA has no way of knowing plot owners who have paid land taxes from the Land Registry because the Land Register is not integrated with the Tax Register. This type of database when implemented would facilitate access of such information to the KRA as the PIN Numbers are integrated with the Land Registry Numbers in the Database.

Table 5.9 Label Query to show PIN Numbers of plot owners (Source; Lab work)

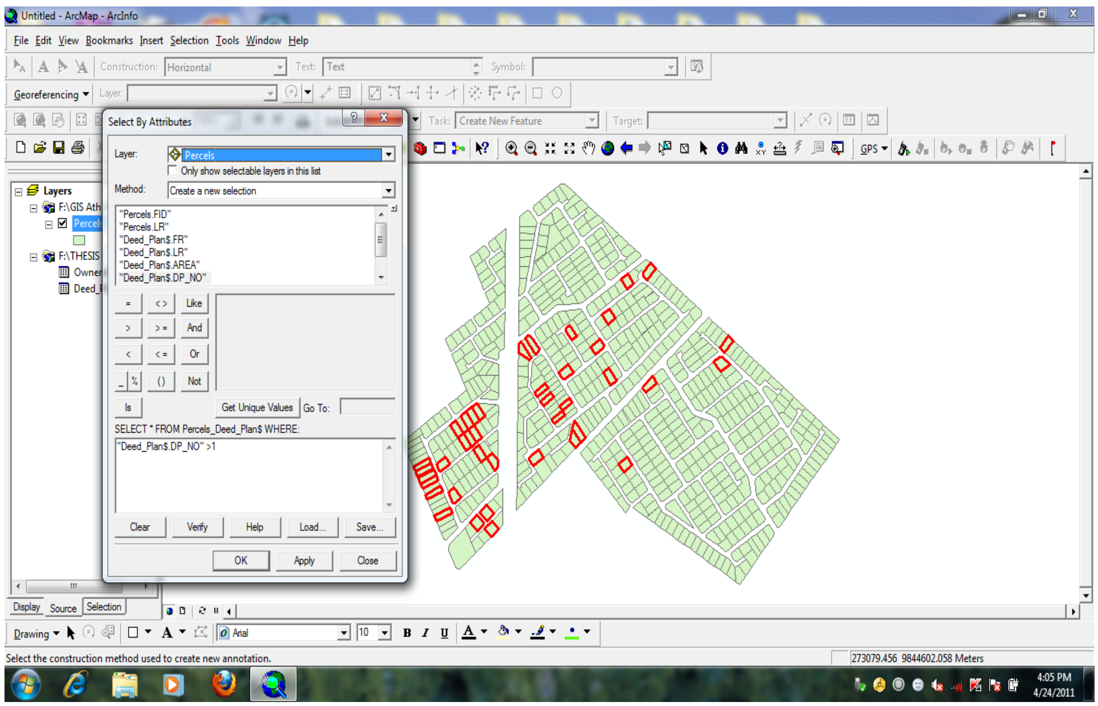


The query of selected plots is useful in isolating a group of land parcels of interest. For example, the Commissioner of Lands may want to know which plots have their leases expiring at a particular time. Currently, this information is in old files in different places in the Land Registry; which is difficult to access. Table 5.10 shows the selected 40 plots for database development.

The issue of leases is particularly important in Kenya as the application for their renewal has to be made by the proprietor or the appointed heirs. In some instances the original proprietor is dead without a will or heir in which case the plot reverts back to the state as *Bona Vacatia*. The Commissioner needs to be able to isolate such plots in time in order to avoid misuse of the properties from fraudulent land officers.

The query indicated in Table 5.11 shows the names of the plot owners. This is one of the most commonly required information when plots are supposed to be sold. In most cases, professionals such as Surveyors need to connect the plot ownership with the survey plan number (i.e. the F/R No). At the moment, this is cumbersome as the two sets of data are kept separately at the Director of Survey offices and the Land Registry respectively. Once the data are integrated in one database, it is easy to access both sets of information efficiently.

Table 5.10 Query of selected forty plots in the study area (Source: Lab work)



This particular query also shows proprietors who own more that one plot (i.e. M: 1 relationship) in a particular scheme. For example, Mr. Machayo owns two plots LR Nos. 26699/900 and 26699/899 (shown in blue in the database). Such information is important in plots allocation so that those who already have more than one plot are not allocated additional plots while others who do not have any miss plots.

The query presented in Table 5.12 shows plots which have areas greater than 0.06Ha. Area is an important component in land transactions in Kenya. Generally, the area of the plot shown in the title deed should be the same as the area in the authenticated survey plan. Currently, the Commissioner of Lands (CoL) has to send for the survey plan from the Department of Survey to verify the area to an interested party. With the creation of a cadastral database, it would be easy for the CoL or any member of the public to check and verify the area of any property without referring to Department of Survey all the time

Table 5.11 Query showing multi plot ownership (1:M) Relationship (Source; Lab work)

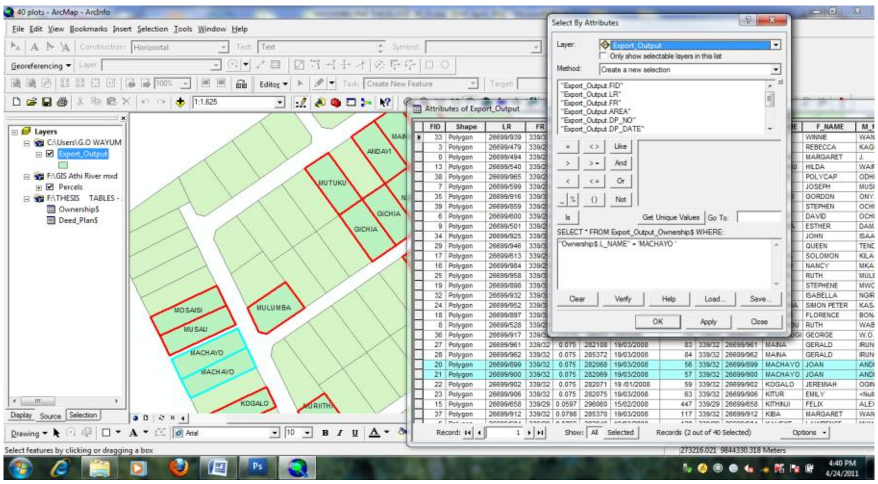
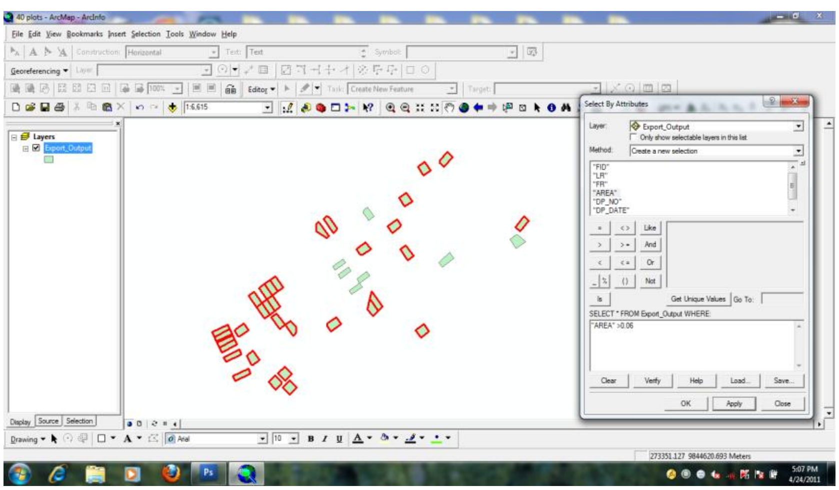


Table 5.12 Plots whose areas are greater than 0.06ha in Red (selection) (Source: Lab work)



The query presented in Table 5.13 is important for clients interested in identifying plots that are developed and those which are not developed. This is particularly important for plot purchasers who are keen to know undeveloped plots. In many instances, the CoL is interested in knowing the status of a plot before giving consent for transfer. This query would facilitate quick identification of such parcels of land without resorting to old land files kept in analogue format.

Table 5.17 presents the result of a query to show plots owned by more than one person i.e. the many to one relations (M:1). This procedure could not be achieved through *simple relates* operations as the ones indicated above. Instead, the spatial data contained in the Excel tables and the digital map of selected 40 plots had to be migrated to ArcMap. Using the ArcCatalogue, these data were brought together in a geodatabase and special relates were created between the PIN Number and National ID Tables and between the 40 plots and the PIN Number. The geodatabase and the RELATES are shown in Table 4.19.

In order to label the multi-owned plots onto the digital cadastral map, the geodatabase was opened in ArcMap and Table 4.20 shows the database and the relates. Table 4.21 shows the window version of the geodatabase together with the plot (L.R.Nos. 26699/898) owned by Mr Tanui Joseph Kibet and Kibet Anne Karegi. It also shows the National Id Numbers of the owners and other attributes about the plot.

Table 5.13 Developed plots in Red and undeveloped plots in Blue (Source: Lab work)

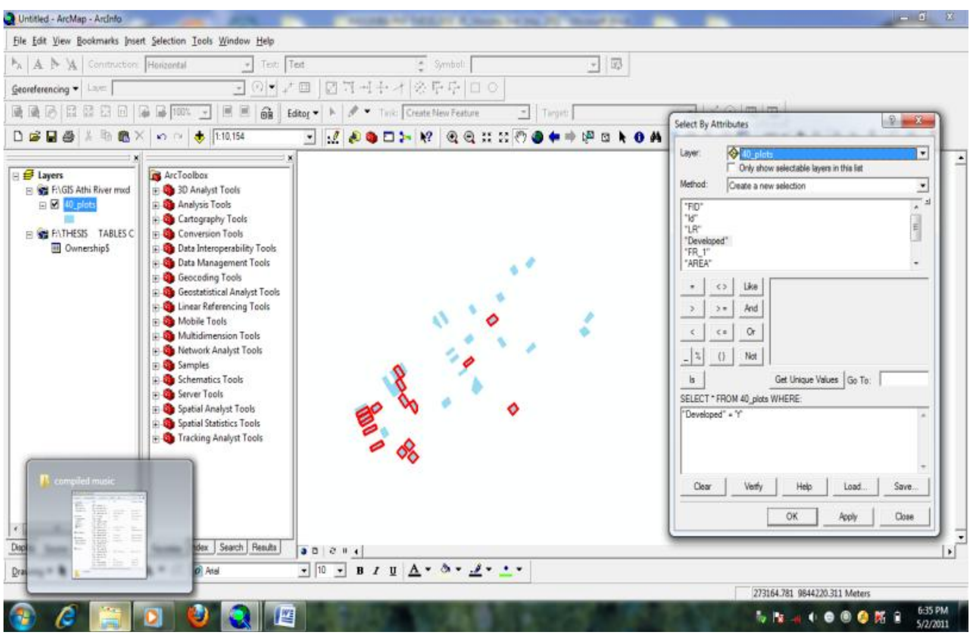


Table 5.14 Geodatabase containing files and relates (Source: Lab work)

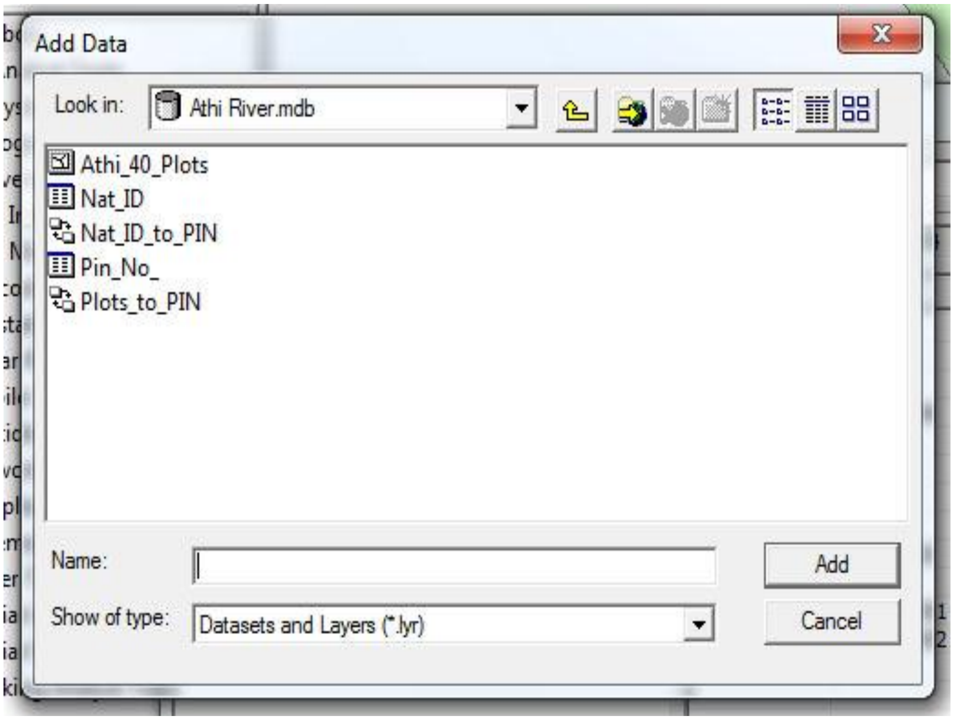
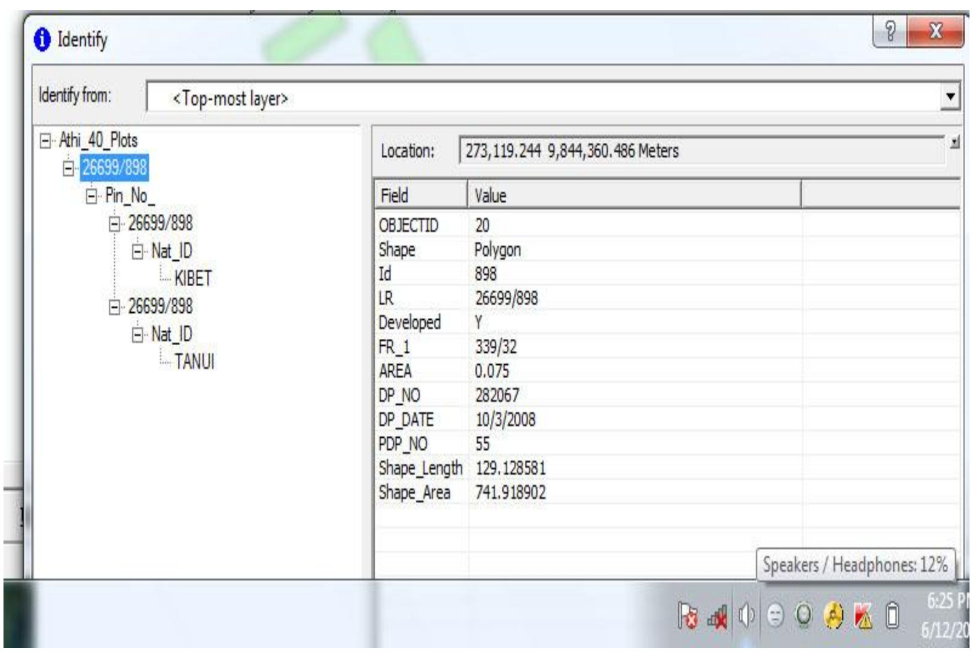


Table 5.15 Selected multiple owned plots in ArcMap (1:M) Relationship (Source: Lab work)



In order to label the relates onto the digital cadastral map of the study area, two scripts were used. The UiButton script (code) which adds the labelling buttons to the ArcMap. This is the interface that operates in the background in the ArcMap, and the Add Labelling Script (code) which labels the plots onto the cadastral digital map as shown in Table 4.22. The two scripts are presented at Appendices 9 and 10. Infact, Stoimenov et al. [1998] have observed that M:1 associations require separate relations to be created in order for the query processes to be implemented.

Table 5.16 Plot L.R.Nos 26699/898 and the relates in ArcMap (Source; Lab work)

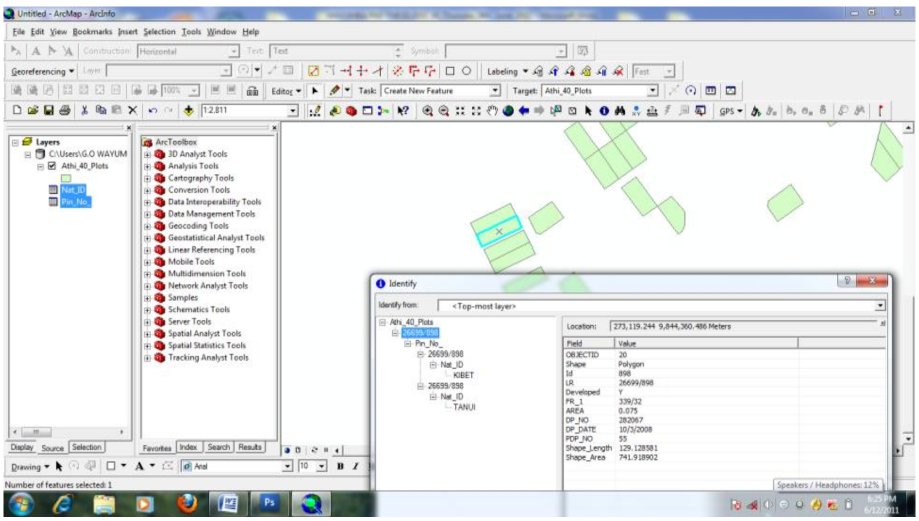


Table 5.17 Multi-Owned plots labeled onto the cadastral digital map (Source: Lab work)

5.7.5 The Cadastral Database Model

Query operations in the database were implemented through the standard Structured Query Language (SQL) as the querying systems for the OODBMS are not yet well developed. Mitrovic [1999] has reported that work on the SQL3 standard for querying the purely OODBMS is still under development, and until such query system are finalized, the hybrid systems will continue to rely on the SQL commands for its query operations.

Stoter [2004] has recommended the use of the Object-Relational models in the development of geospatial databases. The main argument is that Object relational models introduce the advantages of Object oriented models in the relational models. While in the relational databases the set of data types are fixed in the object relational models, this limitation is overcome because of the built-in-support user-defined Abstract Data Types. For example, classes in object oriented technology, a user-defined type consists of (internal) attributes and member functions to access the attributes of the functions.

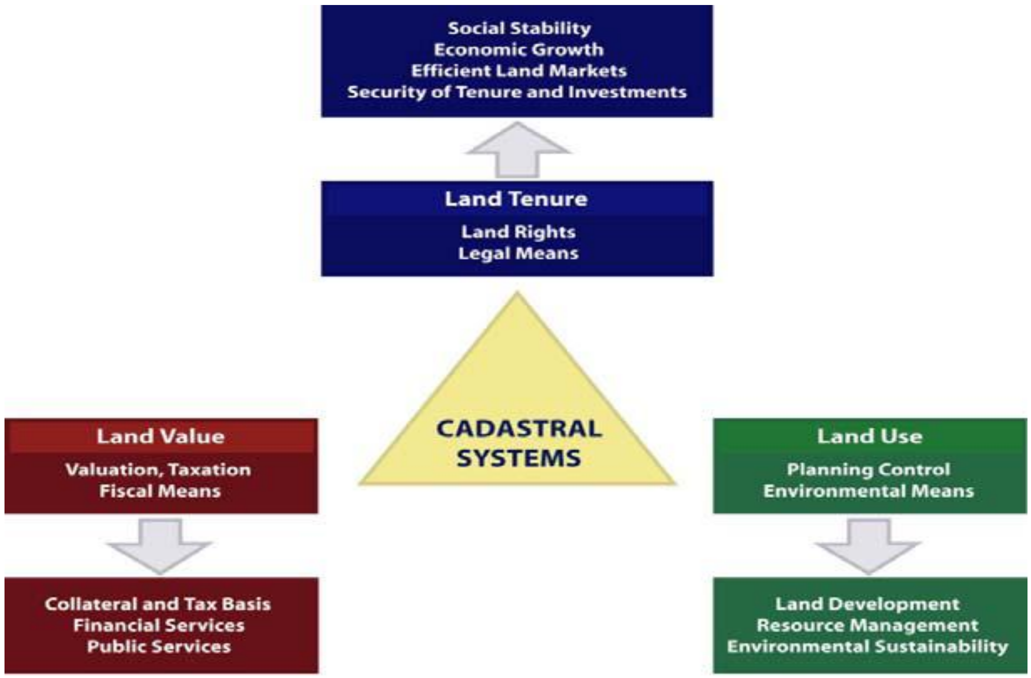


Fig 5.16 The cadastral Systems in sustainable development [Enemark, 2004]

Development of cadastral databases places cadastral information at the centre of the new land management paradigm for sustainable development. Enemark [2004] observed that cadastral information layer is unique and cannot be replaced by any other spatial information. The unique cadastral capacity is to identify a parcel of land both on the ground and in the spatial systems in a way that all stake-holders can relate to. Typically, this consists of an address and a systematically georeferenced coordinate system in a particular projection.

The core cadastral information of parcels, properties, buildings, and roads thus become the core of the Spatial Data Infrastructure information. This in turn feeds into other datasets such as; utility infrastructure, hydrology, vegetation, topography, images and several other applications. The central location of the cadastral system as a provider of basic infrastructure for the interrelated systems in the areas of land tenure, value, use and development is well documented by Enemark [2004]. Basically, without cadastral information, (Figure 5.16) many sustainable development needs would not be realized. Thus the development of the prototype cadastral database in this study provides a unique spatial information-framework for various sectors of the Kenyan economy.

CHAPTER SIX

CONCLUSION

6.1 Introduction

This study sought to evaluate the current cadastral system in Kenya, identify and analyze the appropriate techniques and strategies for the future needs of Kenya's Cadastre, and test the suitability of the identified techniques and strategies in the Cadastral System with a view to recommending modernization strategies. The main concern of the study was that despite many attempts to modernize the cadastral system in Kenya, proper strategies for modernization are lacking. It is therefore expected that when the government is ready to implement the modernization of the cadastral system, the results of this study will be found useful.

6.2 Summary

This study set out to evaluate the cadastral system in Kenya and propose strategies for its modernization. The main rationale for carrying out the study is that since 1903 when the cadastral system in Kenya was established, it has remained more or less the same and basically managed in a manual manner. With the expanding user requirements, the manual operating system has become cumbersome and fraught with delays in searches. There have also been problems with access to land records sue to the different users looking for the same information.

Additional problems with the current cadastral system in Kenya are; storage of paper records is increasingly becoming expensive, with a slow retrieval and replacement time. Paper records also frequently disappear and the provision of access leads to inadequate up-dating, poor cross referencing and generally poor record maintenance. This poor state of affairs informed the implementation of this study in order to develop strategies for improving the current situation. UNCHS [2001] recommended computerization as a the main solution to the above challenges. Further, the Kenya Vision 2030 and its First

Millenium Term Plan [MoL, 2011] have also identified that the main flagship projects to improve the cadastral system in Kenya lies in; modernization of Land Registries and development of National Land Information System.

In the process of fulfilling this mandate, several approaches were adopted which included; a user needs assessment on various stake holders in order to assess their feelings on the structure, its operations and what recommendations they would give towards improving the performance of the system; testing of several geospatial technologies to determine their suitability for cadastral mapping and modelling in Kenya; and development and testing a GIS-based cadastral model.

The results obtained from the evaluation exercise can be summarized into two main categories; strengths and weaknesses. The main strengths are; the cadastral structure has promoted a vibrant property market in Kenya over the years, the massive land adjudication programme which was initiated in the country in 1954, has enabled millions of indigenous Kenyans to acquire title deeds.

Settlement schemes that were inaugurated in 1962 have settled at least 305,890 families in 469 settlement schemes, covering some 1,325 hectares of land. Other strengths include; formation of cooperative farms where 2,700 cooperative farms covering an area of 2.2 million hectares have been subdivided. In terms of allocation of Government grants since 1902 when the Crown Lands was enacted, 250,000 plots have been allocated and 4, 475, 870 titles have been issued.

In terms of and policy, the government produced Kenya Constitution 2010 and passed the Sessional Paper Number 3 on National Land Policy in the year 2009. The government has also recently enacted several legislations governing land. The weaknesses of the system were as follows; the administrative structure is bureaucratic, complex and highly centralized. The cadastral processes are also complex, duplicative and slow. Other weaknesses were observed to include; a complicated land tenure system, low cadastral coverage for the whole country, lack of quick adoption of modern technologies in cadastral mapping and modelling, and lack of development of 3-D Cadastre. All the geospatial technologies tested were found suitable for cadastral mapping and modelling, however, the GPS technology lacks user-guidelines and calibration bases. RTK-GPS was particularly found useful in re-establishment of beacons to 3cm accuracy.

In terms of cadastral modelling, it was observed that Smiths Normalization procedure and Functional Dependency Diagrams automatically generates fully Normalized Tables and successfully queries multiple-plot ownership. This was observed as a major breakthrough for the research in that it has not been possible to successfully query and display multi-plot ownership with Codes Normalization procedures. The study also found out that a hybrid of Object-Relational Database Management system is better suited for the development of modern cadastral databases than typical Relational or Object-Oriented on their own.

The study concluded that the main problem with the cadastral system in Kenya is lack of computerization and over concentration in Nairobi. The study therefore recommends that in order to modernize the system, there should be a process of decentralization and comprehensive computerization of all operations of the system. In constituting the computerization programme, National Land Information System should be developed to take care of land records and data sharing.

Further recommendations are that; al cadastral l boundaries should be georeferenced with GPS and use of Remote Sensing Imagery and GIS should be employed as standard tools in the cadastral system in order to enhance accuracy, speed and cost of doing surveying.

6.3 Conclusions

In view of the foregoing, this study draws the following conclusions:

- The organizational structure of the system is rigid and centralized. The processes are bureaucratic, duplicative and slow in several areas. This validates the initial concerns about the ineffectiveness of the system towards quick service delivery.

- Data storage and handling is manual-based leading to poor data access and transfer. This is increasingly becoming expensive, with a slow retrieval and replacement rate; and confirms frequent complaints about the disappearance of land records at the Ministry of Lands.

- The RTK GPS establishes boundary positions as accurately as the conventional systems, and high spatial resolution satellite imagery provide the same level of accuracy as aerial photography in cadastral mapping. This study noted that the use of geospatial technologies in cadastral mapping and modelling is still scanty in Africa. The results obtained from this study therefore provide a basis for further research.

- Smiths Normalization procedures enable querying of multi-plot ownerships in the database; a situation which has, hitherto not been achieved under the typical Codes Normalization procedures. This is a useful contribution to cadastral modelling in Africa where advanced cadastral modelling systems are still scanty.

- A highbrid of Object-Relational database model is most appropriate for the development of GIS-Based cadastral databases than typical Relational or Object-Oriented on their own. The use of a hybrid of Object-Relational Database systems in the development of modern cadastre, demonstrates the versatility of the GIS technology in cadastral modelling.

- Kenya government has fulfilled Statements Number Five and Number Six of Cadastre 2014 and Statement Number One of Cadastre 2034. The other mandates in both models will take a long time before they can be implemented.

- The Land Registration Act mandates offers an opportunity for minimizing boundary disputes through the georeferencing procedures.

- The Land Act will greatly improve the performance of the current cadastral system through the amalgamation of several registration Acts which are currently complex and difficult to implement.

6.4 Recommendations

Based on the analysis of the research findings, this study gives the following recommendations:

- Decentralization of the administrative structure of the Lands and Survey departments, and adaptation of e-government procedures so as to optimize efficiency and reduce land-related transaction costs.

- Promotion of prudent management of natural resources, recognition of existing communal land rights, and community/indigenous land tenure systems that enhance sustainability and protection of environment.

- Decentralization of land registration systems, digitization/computerization of cadastral records and embracing the concept of e-conveyancing

- Georeferencing all boundaries with Satellite Position Systems, implement Land Information Management System, National Spatial Data Infrastructure by using GIS and Remote Sensing as standard tools in cadastral systems so as to enhance accuracy, speed, and economy.

- Adoption of principles of Cadastre 2014 to enhance the quality of the administration and performance of the present cadastre; and aim at implementing Cadastre 2034 as soon as it is formerly approved by the international geospatial community.

6.5 Areas for Further Research

From this study, the following issues have been identified to be followed up for future researcher:

- The Government of Kenya is moving to adjudicate land rights in the Arid and Semi Arid Areas (ASALS). The current tools for land adjudication assume a sedentary type of life that is practiced in the high potential areas. In the ASALs, the inhabitants are nomadic and their pastoral tenure is little understood. There is therefore a need for further research to understand the land tenure systems among the pastoralists before the adjudication process can proceed

- Cloud mapping is emerging as a new tool for data storage and sharing. Many countries in the West have already loaded their cadastre in the cloud. However, this is an area which is not yet well understood as far as the security of the cadastral data is concerned. It is therefore recommended that further research be carried out in this area to formulate ways of utilizing such facilities.

- While carrying out the study, the researcher attempted to develop a cadastral database for the Kenya cadastre based on Object-Oriented Database Systems. After developing the complete database structure, it was not possible to query the system due to problems of Normalization. This is an area recommended for further research as it would greatly support the implementation of Land Administration Domain Model in Kenya.

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Appendices

Appendix 1 Questionnaire and cover letter.

I am carrying out a PhD study on the cadastral system in Kenya. The specific topic is "An Evaluation of the Cadastral System in Kenya and a strategy for its modernization: The Application of Geospatial Technologies in Cadastral Mapping and Modeling"

In this regard I am requesting for your participation in this research as a member of the Afya Sacco Cooperative. All the information obtained from the respondents will be kept confidential and will never be divulged without your written consent.

There are 628 plots in the study area but I have chosen only forty (40) for development of the proto type database. If you are willing to participate in the study, please fill in the attached questionnaire and sign at the bottom as an indication that you gave the information willingly and without any coercion whatsoever.

Thank you in advance for your cooperation.

Yours Faithfully,
Gordon Wayumba
PhD Candidate
Department of Geospatial and Space Technology,
University of Nairobi.

Appendix 2 Questionnaire for members of the Afya Sacco

Part I: General Information

Could you please supply the following information about yourself and the land parcel you have in Mavoko Municipality.

1. Personal Data Class

   Name
   Date of Birth (Age)
   Address
   ID No.
   Passport No. (if available)
   E-Mail Address
   Gender: Male Female

   Owner Photo Available: Yes ☐ No ☐

2. Land Parcel Class

   The Land Registration Number
   Title Deed No. (IR)
   Date of Registration

3. Encumbrances

   Are there any encumbrances on the land. Please specify
   e.g. Loan Mortgage
   Charge Easement Way leave other

   Who is instituted the encumbrance
   Area offered by the encumbrance

4. Building Class

   Do you have a building on the plot
   Yes No
   If yes, answer the following questions
   Building No:
   Building Value:
   Building Type: Bungalow Town House Flat Other (specify)
   Photograph of the Building: Yes No
   Area occupied by the building:
   Name of Architect:
   Water Meter No
   Power Meter No
   Approved plan No

5. Water Bill Class
   Water Meter No
   Approximate Bill paid per month
   Postal Address No
   Personal ID No
   Building ID No
   Location Name
   Type of Supply
   Account Name and Number
   Parcel ID

6. Power Bill Class
   Meter No
   Account Name
   Owner ID
   Building ID
   Location Name

Parcel ID

Type of Supply	Solar	KPLC	Biogas	Other

7. Taxation Class

Owner ID
Name
PIN No
VAT No
Land Rate Paid per Year
Land Rent Paid per Year

Appendix 3 Ownership Table

FR	LR	L_NAME	F_NAME	M_NAME
339/32	26699/898	TANUI	JOSEPH	KIBET
339/32	26699/898	KIBET	ANNE	KAREGI
339/32	26699/900	MACHAYO	JOAN	ANDISI
339/32	26699/899	MACHAYO	JOAN	ANDISI
339/32	26699/897	MOSAISI	FLORENCE	BONANERI
339/32	26699/961	MAINA	GERALD	IRUNGU
339/32	26699/962	MAINA	GERALD	IRUNGU
339/32	26699/947	GICHIA	PAUL	KIBITHE
339/32	26699/948	GICHIA	PAUL	KIBITHE
339/32	26699/960	ANDAYI	FRANCIS	WECHE
339/32	26699/925	OBIYE	JOHN	ISAAC
339/32	26699/952	MULUMBA	SIMON PETER	KASANGA
339/32	26699/916	OKUNYO	GORDON	ONYANGO
339/32	26699/917	MAKOYUGI	GEORGE	W.O.
339/32	26699/912	KIBA	MARGARET	WANGARI
339/32	26699/906	KITUR	EMILY	
339/32	26699/902	KOYENGO	GLADYS	OKAKAH
339/32	26699/902	KOYENGO	LORRAINE	AKINYI
339/32	26699/939	WARUI	WINNIE	WANGARE
339/32	26699/946	NZEKA	QUEEN	TENDALOIN
339/32	26699/932	MURIITHI	ISABELLA	NGIRA
339/32	26699/958	MUTUKU	RUTH	MULEE
339/29	26699/604	OMONDI	TOM	ONYANGO
339/29	26699/604	OKOTH	EVALYN	ADOYO
339/29	26699/600	OKACH	DAVID	OCHIENG
339/29	26699/965	OYARE	POLYCAP	ODHIAMBO
339/29	26699/494	TALLAM	MARGARET	J.
339/29	26699/473	ADAMBA	JULIA	ASEYO
339/29	26699/475	ILAMBO	MARY	ATAMBA
339/29	26699/490	KARIUKI	MICHAEL	NJENGA
339/29	26699/479	WAKA	REBECCA	KAGEHA
339/29	26699/599	OTIN	JOSEPH	MUSITA
339/29	26699/528	MASAMBU	RUTH	WABAFU
339/29	26699/510	AGUTU	DICKSON	OKUMU
339/29	26699/501	ODANGA	ESTHER	DAMAR
339/29	26699/519	AHOMO	JOSEPH	MUGWANGA
339/29	26699/658	MUTINDA	CATHERINE	M.
339/29	26699/658	MUSYOKI	HUDSON	N.
339/29	26699/557	ASANGA	DANIEL	CHEPKWONY
339/29	26699/540	RUKUNGU	HILDA	WAIRIMU
339/29	26699/547	ABELE	MILDRED	
339/29	26699/613	NDENGA	SOLOMON	KILAHA
339/29	26699/859	OKIL	STEPHEN	OCHIENG
339/29	26699/984	KAHUKI	STEPHEN	KAMAU
339/29	26699/984	KAHUKI	SHEILA	KAWIRA

Appendix 4 Surveyor Table

FR	SURVEYOR_ID	REG_DATE	AUTH_DATE	COORD_TYPE	COMPS_ NO.	FILE_REF. NO.	FIELD BOOK NO
339/32	143	18/09/2006	8/11/2006	UTM	54/46 VOL. I-III	CT/221/71/77	13301 VOL I -IV
339/32	143	18/09/2006	8/11/2006	UTM	54/46 VOL. I-III	CT/221/71/77	13301 VOL I -IV
339/32	143	18/09/2006	8/11/2006	UTM	54/46 VOL. I-III	CT/221/71/77	13301 VOL I -IV
339/32	143	18/09/2006	8/11/2006	UTM	54/46 VOL. I-III	CT/221/71/77	13301 VOL I -IV
339/32	143	18/09/2006	8/11/2006	UTM	54/46 VOL. I-III	CT/221/71/77	13301 VOL I -IV
339/32	143	18/09/2006	8/11/2006	UTM	54/46 VOL. I-III	CT/221/71/77	13301 VOL I -IV
339/32	143	18/09/2006	8/11/2006	UTM	54/46 VOL. I-III	CT/221/71/77	13301 VOL I -IV
339/32	143	18/09/2006	8/11/2006	UTM	54/46 VOL. I-III	CT/221/71/77	13301 VOL I -IV
339/32	143	18/09/2006	8/11/2006	UTM	54/46 VOL. I-III	CT/221/71/77	13301 VOL I -IV
339/32	143	18/09/2006	8/11/2006	UTM	54/46 VOL. I-III	CT/221/71/77	13301 VOL I -IV
339/32	143	18/09/2006	8/11/2006	UTM	54/46 VOL. I-III	CT/221/71/77	13301 VOL I -IV
339/32	143	18/09/2006	8/11/2006	UTM	54/46 VOL. I-III	CT/221/71/77	13301 VOL I -IV
339/32	143	18/09/2006	8/11/2006	UTM	54/46 VOL. I-III	CT/221/71/77	13301 VOL I -IV
339/32	143	18/09/2006	8/11/2006	UTM	54/46 VOL. I-III	CT/221/71/77	13301 VOL I -IV
339/32	143	18/09/2006	8/11/2006	UTM	54/46 VOL. I-III	CT/221/71/77	13301 VOL I -IV
339/32	143	18/09/2006	8/11/2006	UTM	54/46 VOL. I-III	CT/221/71/77	13301 VOL I -IV
339/32	143	18/09/2006	8/11/2006	UTM	54/46 VOL. I-III	CT/221/71/77	13301 VOL I -IV
339/32	143	18/09/2006	8/11/2006	UTM	54/46 VOL. I-III	CT/221/71/77	13301 VOL I -IV
339/32	143	18/09/2006	8/11/2006	UTM	54/46 VOL. I-III	CT/221/71/77	13301 VOL I -IV
339/32	143	18/09/2006	8/11/2006	UTM	54/46 VOL. I-III	CT/221/71/77	13301 VOL I -IV
339/29	143	18/09/2006	8/11/2006	UTM	54146 VOL I-IV	CT/221/70/77	13301/VOL I -II
339/29	143	18/09/2006	8/11/2006	UTM	54146 VOL I-IV	CT/221/70/77	13301/VOL I -II
339/29	143	18/09/2006	8/11/2006	UTM	54146 VOL I-IV	CT/221/70/77	13301/VOL I -II
339/29	143	18/09/2006	8/11/2006	UTM	54146 VOL I-IV	CT/221/70/77	13301/VOL I -II
339/29	143	18/09/2006	8/11/2006	UTM	54146 VOL I-IV	CT/221/70/77	13301/VOL I -II
339/29	143	18/09/2006	8/11/2006	UTM	54146 VOL I-IV	CT/221/70/77	13301/VOL I -II
339/29	143	18/09/2006	8/11/2006	UTM	54146 VOL I-IV	CT/221/70/77	13301/VOL I -II
339/29	143	18/09/2006	8/11/2006	UTM	54146 VOL I-IV	CT/221/70/77	13301/VOL I -II

339/29	143	18/09/2006	8/11/2006	UTM	54146 VOL I-IV	CT/221/70/77	13301/VOL I -II
339/29	143	18/09/2006	8/11/2006	UTM	54146 VOL I-IV	CT/221/70/77	13301/VOL I -II
339/29	143	18/09/2006	8/11/2006	UTM	54146 VOL I-IV	CT/221/70/77	13301/VOL I -II
339/29	143	18/09/2006	8/11/2006	UTM	54146 VOL I-IV	CT/221/70/77	13301/VOL I -II
339/29	143	18/09/2006	8/11/2006	UTM	54146 VOL I-IV	CT/221/70/77	13301/VOL I -II
339/29	143	18/09/2006	8/11/2006	UTM	54146 VOL I-IV	CT/221/70/77	13301/VOL I -II
339/29	143	18/09/2006	8/11/2006	UTM	54146 VOL I-IV	CT/221/70/77	13301/VOL I -II
339/29	143	18/09/2006	8/11/2006	UTM	54146 VOL I-IV	CT/221/70/77	13301/VOL I -II
339/29	143	18/09/2006	8/11/2006	UTM	54146 VOL I-IV	CT/221/70/77	13301/VOL I -II
339/29	143	18/09/2006	8/11/2006	UTM	54146 VOL I-IV	CT/221/70/77	13301/VOL I -II
339/29	143	18/09/2006	8/11/2006	UTM	54146 VOL I-IV	CT/221/70/77	13301/VOL I -II
339/29	143	18/09/2006	8/11/2006	UTM	54146 VOL I-IV	CT/221/70/77	13301/VOL I -II

Appendix 5 National ID Table

PERS_ID	NAT_ID	L_NAME	F_NAME	M_NAME
A001747745G	5043979	TANUI	JOSEPH	KIBET
A001747747G	5750602	KIBET	ANNE	KAREGI
A001249173Y	8717928	MACHAYO	JOAN	ANDISI
A002012483H	11323105	MOSAISI	FLORENCE	BONANERI
A001602159Q	7802546	MAINA	GERALD	IRUNGU
A001985343E	10875753	GICHIA	PAUL	KIBITHE
A002944998G	13347322	ANDAYI	FRANCIS	WECHE
A001217160M	5807356	OBIYE	JOHN	ISAAC
A002270863N	13490670	MULUMBA	SIMON PETER	KASANGA
A001203333Y	2688912	OKUNYO	GORDON	ONYANGO
A001347621N	6402370	MAKOYUGI	GEORGE	W.O.
A000095639R	997956	KIBE	MARGARET	WANGARI
A002479195M	14516094	KITUR	EMILY	
A001572538S	8341864	KOYENGO	GLADYS	OKAKAH
A002416468A	1462093	KOYENGO	LORRAINE	AKINYI
A001908025X	3094638	WARUI	WINNIE	WANGARE
A001814241Z	9584364	NZEKA	QUEEN	TENDALOIN
A001310476J	9250032	MURIITHI	ISABELLA	NGIRA
A001560191K	904782	MUTUKU	RUTH	MULEE
A001731735M	3481462	OMONDI	TOM	ONYANGO
A001816497Z	2399778	OKOTH	EVALYN	ADOYO
A001599122Y	10011114	OKACH	DAVID	OCHIENG
A001355912J	1572429	OYARE	POLYCAP	ODHIAMBO
A001162415T	6342911	TALLAM	MARGARET	J.
A001350700U	9666203	ADAMBA	JULIA	ASEYO
A001137270M	6627908	ILAMBO	MARY	ATAMBA
A001358071W	3429001	KARIUKI	MICHAEL	NJENGA
A001360382L	4178411	WAKA	REBECCA	KAGEHA
A001451184L	4037052	OTIN	JOSEPH	MUSITA
A001576284H	7597980	MASAMBU	RUTH	WABAFU
A001125768S	10330039	AGUTU	DICKSON	OKUMU
A001143000L	10366553	ODANGA	ESTHER	DAMAR
A001451739K	8248911	AHOMO	JOSEPH	MUGWANGA
A002604061Z	13406650	MUTINDA	CATHERINE	M.
A002604062Z	11862029	MUSYOKI	HUDSON	N.
A001256924Q	4756638	ASANGA	DANIEL	CHEPKWONY
A001614519M	995437	RUKUNGU	HILDA	WAIRIMU
A001339384B	9955548	ABELE	MILDRED	
A001439801Q	999235	NDENGA	SOLOMON	KILAHA
A001726726Z	8606180	OKIL	STEPHEN	OCHIENG
A001526785M	10755083	KAHUKI	STEPHEN	KAMAU
A001687404W	1888680	KAHUKI	SHEILA	KAWIRA

Appendix 6 Passport Table

PERS_ID	ID_SW	PASSPORT_ID	L_NAME	F_NAME	M_NAME	NATIONALITY
A001747745G		A743378	TANUI	JOSEPH	KIBET	Kenyan
A001747747G		A743376	KIBET	ANNE	KAREGI	Kenyan
A002012483H		A624746	MOSAISI	FLORENCE	BONANERI	Kenyan
A001217160M		A536847	OBIYE	JOHN	ISAAC	Kenyan
A001347621N		A698761	MAKOYUGI	GEORGE	W.O.	Kenyan
A001814241Z		A4765239	NZEKA	QUEEN	TENDALOIN	Kenyan
A001731735M		A764096	OMONDI	TOM	ONYANGO	Kenyan
A001162415T		A985022	TALLAM	MARGARET	J.	Kenyan
A001451184L		A387212	OTIN	JOSEPH	MUSITA	Kenyan
A001451739K		A624091	AHOMO	JOSEPH	MUGWANGA	Kenyan
A001439801Q		A623105	NDENGA	SOLOMON	KILAHA	Kenyan

Appendix 7 Deed Plans Table

FR	LR	AREA	DP_NO	DP_DATE	PDP_NO
339/32	26699/898	0.075	282067	10/3/2008	55
339/32	26699/900	0.075	282069	19/03/2008	57
339/32	26699/899	0.075	282068	19/03/2008	56
339/32	26699/897	0.075	282066	19/03/2008	54
339/32	26699/961	0.075	282108	19/03/2008	83
339/32	26699/962	0.075	285372	19/03/2008	84
339/32	26699/947	0.0753	282097	19/03/2008	78
339/32	26699/948	0.0753	282098	19/03/2008	77
339/32	26699/960	0.075	282107	19/03/2008	80
339/32	26699/925	0.077	296025	6/8/2009	92
339/32	26699/952	0.0745	282102	19/03/2008	69
339/32	26699/916	0.0776	296021	6/8/2009	119
339/32	26699/917	0.0776	296022	6/8/2009	116
339/32	26699/912	0.0798	285370	19/03/2008	117
339/32	26699/906	0.075	282075	19/03/2008	63
339/32	26699/902	0.075	282071	19 /01/2008	59
339/32	26699/939	0.077	282094	19/03/2008	94
339/32	26699/946	0.0753	282096	19/03/2008	81
339/32	26699/932	0.075	296050	19/03/2008	106
339/32	26699/958	0.0804	296045	31/07/2009	75
339/29	26699/604	0.0766	282049	19/03/2008	128
339/29	26699/600	0.0855	282042	19/03/2008	136
339/29	26699/965	0.075	296028	3107/2009	153
339/29	26699/494	0.075	281950	15/02/2008	155
339/29	26699/473	0.0506	281698	16/11/2008	161
339/29	26699/475	0.0506	281700	16/11/2007	165
339/29	26699/490	0.0506	281713	16/11/207	171
339/29	26699/479	0.0506	281704	16/11/2007	173
339/29	26699/599	0.0801	282047	19/03/2008	176
339/29	26699/528	0.0751	281739	16/11/2007	189
339/29	26699/510	0.0782	281954	15/02/2008	200
339/29	26699/501	0.0597	281952	15/02/2008	219
339/29	26699/519	0.079	281957	15/02/2008	225
339/29	26699/658	0.0597	296060	15/02/2008	447
339/29	26699/557	0.072	281967	15/02/2008	244
339/29	26699/540	0.075	281749	16/11/2007	247
339/29	26699/547	0.075	281754	16/11/2007	256
339/29	26699/613	0.0597	295916	6/8/2009	367
339/29	26699/859	0.075	295996	6/8/2009	340
339/29	26699/984	0.075	281942	6/11/2007	607

Appendix 8 Survey Mark Table

FR	LR	SURV_MARK	X	Y	MAR_TYPE	SYSTEM
339/32	26699/898	897D	273088.4655	9844353.802	IPC	UTM
339/32	26699/898	897C	273133.2393	9844375.242	IPC	UTM
339/32	26699/898	898A	273139.6889	9844361.635	IPC	UTM
339/32	26699/898	898B	273094.8871	9844340.41	IPC	UTM
339/32	26699/898	897D	273088.4655	9844353.802	IPC	UTM
339/32	26699/900	899C	273103.5989	9844323.54	IPC	UTM
339/32	26699/900	899B	273147.9823	9844345.648	IPC	UTM
339/32	26699/900	900A	273154.4564	9844331.988	IPC	UTM
339/32	26699/900	900B	273109.8272	9844310.399	IPC	UTM
339/32	26699/899	899A	273141.6893	9844358.926	IPC	UTM
339/32	26699/899	899B	273147.9823	9844345.648	IPC	UTM
339/32	26699/899	899C	273103.5989	9844323.54	IPC	UTM
339/32	26699/899	899D	273096.8875	9844337.7	IPC	UTM
339/32	26699/897	897A	273082.212	9844366.844	IPC	UTM
339/32	26699/897	897B	273126.877	9844388.665	IPC	UTM
339/32	26699/897	897C	273133.2393	9844375.242	IPC	UTM
339/32	26699/897	897D	273088.4655	9844353.802	IPC	UTM
339/32	26699/961	960B	273232.6598	9844503.06	IPC	UTM
339/32	26699/961	961A	273248.4083	9844514.227	IPC	UTM
339/32	26699/961	961B	273271.0884	9844481.959	IPC	UTM
339/32	26699/961	960C	273255.5049	9844470.788	IPC	UTM
339/32	26699/962	961A	273248.4083	9844514.227	IPC	UTM
339/32	26699/962	962A	273263.5572	9844524.969	IPC	UTM
339/32	26699/962	962B	273286.2985	9844492.863	IPC	UTM
339/32	26699/962	961B	273271.0884	9844481.959	IPC	UTM
339/32	26699/947	960B	273262.4768	9844427.349	IPC	UTM
339/32	26699/947	947A	273247.1848	9844416.504	IPC	UTM
339/32	26699/947	947B	273224.6382	9844448.661	IPC	UTM
339/32	26699/947	960D	273239.8514	9844459.566	IPC	UTM
339/32	26699/948	947C	273224.6382	9844448.661	IPC	UTM
339/32	26699/948	947B	273247.1848	9844416.504	IPC	UTM
339/32	26699/948	948A	273231.4728	9844405.361	IPC	UTM
339/32	26699/948	958D	273208.9713	9844437.43	IPC	UTM
339/32	26699/960	960A	273217.0667	9844492.003	IPC	UTM
339/32	26699/960	960B	273232.6598	9844503.06	IPC	UTM
339/32	26699/960	960C	273255.5049	9844470.788	IPC	UTM

FR	LR	SURV_MARK	X	Y	MAR_TYPE	SYSTEM
339/32	26699/960	947D	273239.8514	9844459.566	IPC	UTM
339/32	26699/925	925A	273313.2885	9844354.695	IPC	UTM
339/32	26699/925	925B	273290.2298	9844385.833	IPC	UTM
339/32	26699/925	925C	273306.1209	9844397.079	IPC	UTM
339/32	26699/925	925D	273321.0027	9844379.671	IPC	UTM
339/32	26699/925	925E	273320.8179	9844365.128	IPC	UTM
339/32	26699/925	925F	273317.6663	9844357.8	IPC	UTM
339/32	26699/952	952A	273172.9022	9844390.853	IPC	UTM
339/32	26699/952	952B	273185.8964	9844373.039	IPC	UTM
339/32	26699/952	952C	273160.2061	9844354.82	IPC	UTM
339/32	26699/952	952D	273155.0838	9844356.031	IPC	UTM
339/32	26699/952	952E	273147.0008	9844373.09	IPC	UTM
339/32	26699/916	916A	273311.0891	9844246.866	IPC	UTM
339/32	26699/916	916B	273290.9907	9844228.244	IPC	UTM
339/32	26699/916	916C	273270.9441	9844249.89	IPC	UTM
339/32	26699/916	916D	273291.034	9844268.334	IPC	UTM
339/32	26699/917	917A	273281.4685	9844219.424	IPC	UTM
339/32	26699/917	917B	273264.1475	9844203.378	IPC	UTM
339/32	26699/917	917C	273244.2129	9844225.07	IPC	UTM
339/32	26699/917	917D	273264.3389	9844243.771	IPC	UTM
339/32	26699/917	917E	273281.5081	9844225.233	IPC	UTM
339/32	26699/912	912A	273325.0669	9844208.619	IPC	UTM
339/32	26699/912	912B	273304.429	9844189.5	IPC	UTM
339/32	26699/912	912C	273285.0343	9844209.907	IPC	UTM
339/32	26699/912	912D	273305.9445	9844229.086	IPC	UTM
339/32	26699/906	906A	273142.109	9844242.288	IPC	UTM
339/32	26699/906	906B	273187.0554	9844263.206	IPC	UTM
339/32	26699/906	906C	273193.5352	9844249.535	IPC	UTM
339/32	26699/906	906D	273148.5832	9844228.629	IPC	UTM
339/32	26699/902	902A	273161.0254	9844318.128	IPC	UTM
339/32	26699/902	902B	273167.4549	9844304.562	IPC	UTM
339/32	26699/902	902C	273122.7756	9844283.079	IPC	UTM
339/32	26699/902	902D	273116.5415	9844296.233	IPC	UTM
339/32	26699/939	938A	273250.1671	9844406.849	IPC	UTM
339/32	26699/939	938B	273266.3101	9844418.298	IPC	UTM
339/32	26699/939	938C	273290.2298	9844385.833	IPC	UTM
339/32	26699/939	938D	273274.058	9844374.388	IPC	UTM

FR	LR	SURV_MARK	X	Y	MAR_TYPE	SYSTEM
339/32	26699/946	960C	273255.5049	9844470.788	IPC	UTM
339/32	26699/946	946A	273278.2004	9844438.5	IPC	UTM
339/32	26699/946	946B	273262.4768	9844427.349	IPC	UTM
339/32	26699/946	960D	273239.8514	9844459.566	IPC	UTM
339/32	26699/932	932A	273179.5453	9844299.42	IPC	UTM
339/32	26699/932	932B	273197.4434	9844311.947	IPC	UTM
339/32	26699/932	932C	273216.271	9844285.885	IPC	UTM
339/32	26699/932	932D	273197.5974	9844272.64	IPC	UTM
339/32	26699/932	932E	273191.8009	9844273.559	IPC	UTM
339/32	26699/958	958A	273185.9416	9844469.933	IPC	UTM
339/32	26699/958	958B	273201.6544	9844481.075	IPC	UTM
339/32	26699/958	947C	273224.6382	9844448.661	IPC	UTM
339/32	26699/958	957D	273208.9713	9844437.43	IPC	UTM
339/29	26699/604	604A	273414.0021	9844392.022	IPC	UTM
339/29	26699/604	604B	273439.4002	9844410.037	IPC	UTM
339/29	26699/604	604C	273453.3881	9844389.308	IPC	UTM
339/29	26699/604	604D	273424.3601	9844368.635	IPC	UTM
339/29	26699/604	604E	273413.4248	9844385.163	IPC	UTM
339/29	26699/600	600A	273528.693	9844431.686	IPC	UTM
339/29	26699/600	600B	273535.566	9844461.452	IPC	UTM
339/29	26699/600	600C	273560.4545	9844427.337	IPC	UTM
339/29	26699/600	600D	273545.4242	9844413.412	IPC	UTM
339/29	26699/965	965A	273389.8282	9844679.159	IPC	UTM
339/29	26699/965	965B	273418.5813	9844638.818	IPC	UTM
339/29	26699/965	965C	273412.053	9844634.186	IPC	UTM
339/29	26699/965	965D	273382.192	9844652.577	IPC	UTM
339/29	26699/965	965E	273382.463	9844673.946	IPC	UTM
339/29	26699/494	494A	273402.3618	9844688.03	IPC	UTM
339/29	26699/494	494B	273411.2196	9844694.3	IPC	UTM
339/29	26699/494	494C	273418.2249	9844693.469	IPC	UTM
339/29	26699/494	494D	273441.123	9844661.182	IPC	UTM
339/29	26699/494	494E	273440.0506	9844654.048	IPC	UTM
339/29	26699/494	494F	273430.7325	9844647.437	IPC	UTM
339/29	26699/473	473A	273427.2277	9844553.642	IPC	UTM
339/29	26699/473	473B	273457.2875	9844574.905	IPC	UTM
339/29	26699/473	473C	273465.4197	9844563.652	IPC	UTM
339/29	26699/473	473D	273435.0183	9844542.657	IPC	UTM

Appendix 9 UiButton Script

```
Set pTextSym = pSymSel.GetSymbolAt(0)

Dim pDoc As IMxDocument
Dim pRelClassColl As IRelationshipClassCollection
Dim pRelClass As IRelationshipClass
Dim pLayer As IFeatureLayer
Dim pFc As IFeatureClass
Dim pEnumRelClass As IEnumRelationshipClass
Dim pDs As IDataset
Dim pCur As IFeatureCursor
Dim pFeat As IFeature
Dim pRelObjSet As ISet
Dim pRelRow As IRow
Dim strLabel As String
Dim strExp As String

'Make sure a layer is selected in the Table of Contents
Set pDoc = ThisDocument
Set pLayer = pDoc.SelectedLayer
If pLayerIs Nothing Then
MsgBox "Please Select a layer to label"
   Exit Sub
End If
Set pFc = pLayer.FeatureClass
Set pRelClassColl = pLayer
Set pEnumRelClass = pRelClassColl.RelationshipClasses
Set pRelClass = pEnumRelClass.Next
'Make sure relate was found uses first relate on first layer in the map
If pRelClassIs Nothing Then
MsgBox "No relate on this featureclass"
   Exit Sub
End If

'Get related rows in table and label features
Set pCur = pFc.Search(Nothing, False)
Set pFeat = pCur.NextFeature
Do UntilpFeat Is Nothing
strExp = ""
   Set pRelObjSet = pRelClass.GetObjectsRelatedToObject(pFeat)
     For i = 0 TopRelObjSet.Count - 1
       Set pRelRow = pRelObjSet.Next
       'make sure label field exists in related table
       If pRelRow.Fields.FindField(LabelField) = -1 Then
MsgBoxLabelField&" field doesn't exist"
```

```
        Exit Sub
      End If
strLabel = pRelRow.Value(pRelRow.Fields.FindField(LabelField))
      If Not strExp = "" Then
strExp = strExp&vbNewLine&strLabel
      Else
strExp = strLabel
      End If
    Next i
AddLabelstrExp, pFeat, pTextSym
Set pFeat = pCur.NextFeature
Loop
```

Appendix 10 Add Label Script.

```
Sub AddLabel(strLabel As String, pfeature As IFeature, pTextSym As ITextSymbol)

  Dim pMxDoc As IMxDocument
  Dim pGraphicsContainer As IGraphicsContainer
  Dim pActiveView As IActiveView
  Dim pTextElement As ITextElement
  Dim pElement As IElement

  Set pMxDoc = Application.Document
  Set pGraphicsContainer = pMxDoc.FocusMap
  Set pActiveView = pMxDoc.FocusMap

  Set pTextElement = New TextElement
  Set pElement = pTextElement
pTextElement.Symbol = pTextSym
  'Get the center of the polygon
  Dim pPoly As IPolygon
  Dim pArea As IArea
  Set pPoly = pfeature.Shape
  Set pArea = pPoly
  Dim pPoint As IPoint
  Set pPoint = pArea.Centroid
pTextElement.Text = strLabel
pElement.Geometry = pPoint
pGraphicsContainer.AddElementpTextElement, 0

pActiveView.PartialRefreshesriViewGraphics, Nothing, Nothing

End Sub
```

Appendix 11 List of Cassini Coordinates of the Nucleus Estate (1950) Arc Datum

STATION	Northings (m)	Eastings (m)
A3	-498886.95	49094.72
B2	-490174.82	45478.78
B1a	-494356.06	45444.70
Beac1	-487086.49	49349.44
Beac2	-487112.89	49092.31
Beac4	-485841.11	48290.40
Beac5	-485688.35	48313 .01
Bridge	-482835.60	47390.30
D14	-496133.51	46087.83
D18	-496657.49	47156.28
F16	-491500.42	46974.10
F17	-491893.89	47037.07
Go14	-490064.82	51815.79
Go15	-490093.59	51483.74
Go16	-489836.12	51384.19
Go17	-489661.60	51172.38
Go18	-489110.95	50500.60
Go19	-488707.63	50282.70
Go21	-488462.06	50256.40
Go22	-487693.02	50355.80
Go23	-487512.88	50147.50
Go24	-486764.35	50126.00
Gully	-483854.12	46254.80
Kidiani	-486281.94	43548.09
Nguluku	-487943.26	46541.68
Kibuyuni	-495247.30	46064.61
NE	-493974.73	55044.62
River6	-496451.87	49836.51
Rd12E	-494132.16	48835.15
3A	-495427.96	48647.45
8	-491457.69	53702.10
9	-491502.28	53567.26
10	-491407.80	53456.43
11	-491326.23	53389.26
12	-491257.59	53391.63
14	-490823.68	53203.14
15	-490782.13	52888.93
16	-490752.72	52491.71
17	-490585.84	52203.04
18	-490467.37	52040.18
19	-490379.28	51971.42
20	-490204.57	51884.40
21	-490103.01	51815.79
1B	-491354.54	50954.81
2B	-491383.79	50904.64
3B	-491536.64	50866.07
4B	-491758.58	50752.14
5B	-491883.45	50691.26
6B	-491877.23	50645.67
7B	-491768.08	50625.80
8B	-491716.29	50457.40
9B	-491715.21	50320.73
10B	-491786.99	50121.40
11B	-492645.79	49632.24
12B	-493425.38	49769.81
13B	-491861.80	51837.54
14B	-492821.35	49664.16
15B	-492873.44	49673.28
16B	-491356.60	50985.19
XE	-497611.73	47507.47
SR8E	-497465.45	47636.98
Inter NW	-492704.57	53501.94
RATE	-491544.83	53711.25
RD25E	-493614.30	45924.43
Rd Inter	-492716.21	53516.08
sw	-502438.57	43548.45
SW	-494813.36	47934.01
RD	-491453.24	53715.42
SR9E	-497677.50	47449.25
SR10E	-498187.55	47094.71
SR11E	-498580.99	46752.97
SR12E	-498768.32	46607.61
SR13E	-498974.52	46366.76
SR14E	-499173.43	46066.44
SR15E	-499206.56	45840.34
SR16E	-499352.19	45669.80
SR17E	-499568.54	45455.37
SR19E	-499983.77	44954.86
SR20E	-500111.42	44776.22
SR21E	-500285.37	44255.19
Rd2SW	-500031.35	45509.90
NE	-499846.73	46355.57
Rd1NE	-499764.04	45319.61
2a	-501805.10	44064.51
L4	-501848.48	41959.30
P	-502382.15	42201.75
Z	-499932.90	43465.55

Appedix 12 List of UTM Coordinates of the Nucleus Estate (1960 Arc Datum)

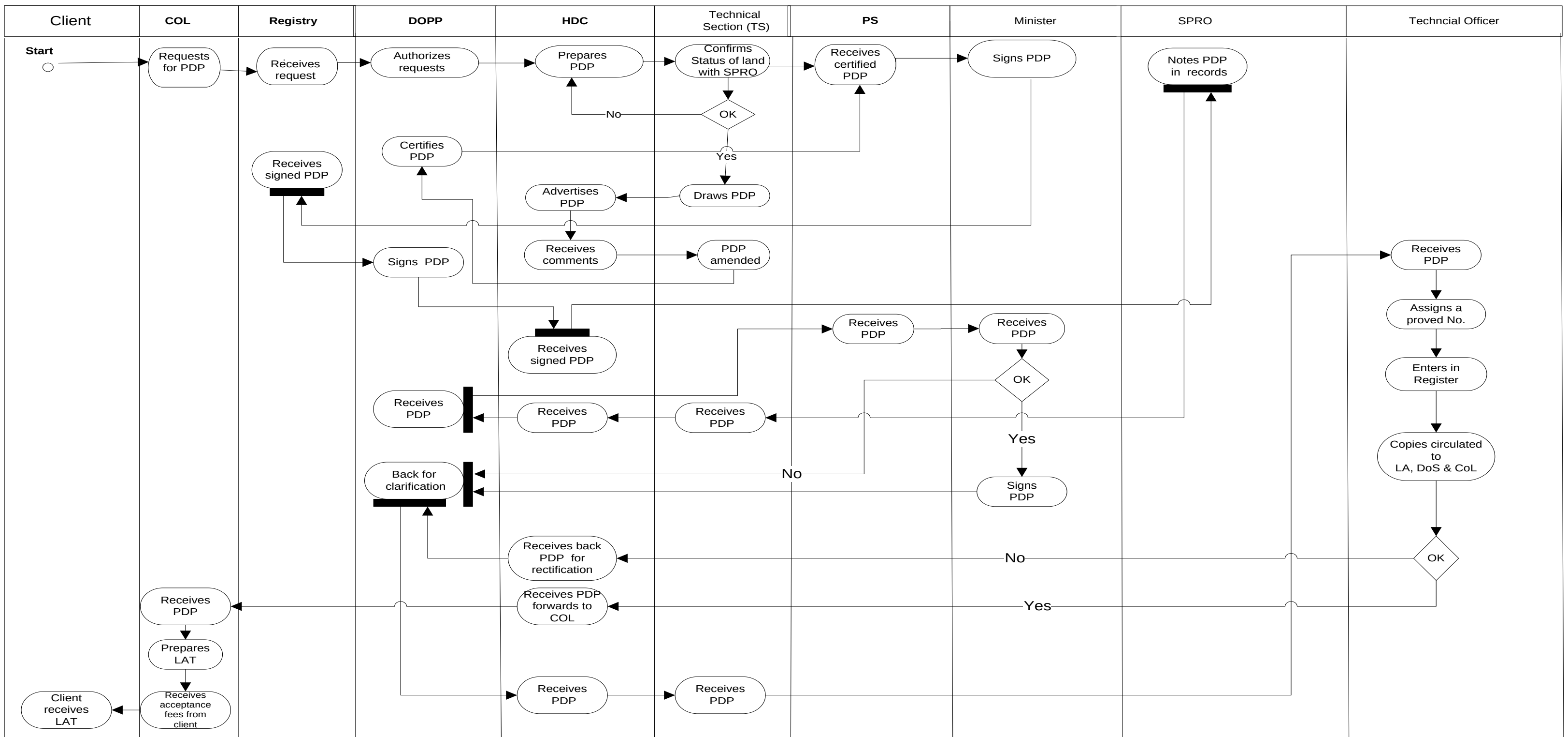
STATION	Northings (m)	Eastings(m)
A3	9501463	549177.1
B2	9510197	545559.4
B1a	9506006	545522.2
Beac1	9513289	549441.1
Beac2	9513263	549183.3
Beac4	9514538	548380.6
Beac5	9514691	548403.3
Bridge	9517551	547480.6
D14	9504224	546165.4
D18	9503698	547235.9
F16	9508867	547057.1
F17	9508473	547119.9
Go14	9510303	551910.8
Go15	9510274	551577.9
Go16	9510532	551478.4
Go17	9510707	551266.2
Go18	9511260	550593.3
Go19	9511664	550375.2
Go21	9511910	550349
Go22	9512681	550449.2
Go23	9512861	550240.6
Go24	9513612	550219.6
Gully	9516531	546341.8
Kidian	9514100	543627.3
Nguluku	9512433	546626.4
Kibiyuni	9505113	546142.8
NE	9506381	555144
River6	9503903	549922.3
Rd12E	9506228	548920.4
3A	9504930	548731.3
8	9508905	553800.3
9	9508861	553665.1
10	9508955	553554.1
11	9509037	553486.8
12	9509106	553489.3
14	9509541	553300.7
15	9509583	552985.8
16	9509613	552587.7
17	9509780	552298.5
18	9509899	552135.4
19	9509987	552066.5
20	9510162	551979.4
21	9510264	551910.7

1B	9509011	551046.9
2B	9508981	550996.6
3B	9508828	550957.8
4B	9508606	550843.5
5B	9508481	550782.4
6B	9508487	550736.7
7B	9508596	550716.8
8B	9508648	550548.1
9B	9508650	550411.1
10B	9508578	550211.3
11B	9507717	549720.4
12B	9506936	549857.7
13B	9508502	551931.2
14B	9507541	549752.3
15B	9507489	549761.4
16B	9509008	551077.3
XE	9502742	547587.2
SR8E	9502888	547717.1
Inter NW	9507656	553598.8
RATE	9508818	553809.4
RD25E	9506749	546003.5
Rd Inter	9507644	553612.9
sw	9497907	543615.7
SW	9505546	548016.7
RD	9508910	553813.6
SR9E	9502676	547528.8
SR10E	9502165	547173.1
SR11E	9501771	546830.3
SR12E	9501583	546684.4
SR13E	9501377	546442.9
SR14E	9501178	546141.8
SR15E	9501145	545915.1
SR16E	9500999	545744.1
SR17E	9500782	545529
SR19E	9500366	545027.1
SR20E	9500239	544847.9
SR21E	9500065	544325.6
Rd2SW	9500318	545583.3
NE	9500503	546431
Rd1NE	9500586	545392.8
2a	9498542	544133.4
L4	9498500	542023.4

Appendix 13 List of UTM Coordinates of the Bumbani plot (1960 Arc Datum)

STATION	NORTHING (Y)	EASTING (X)
BB16	9503928.651	540876.258
P2	9503458.162	541141.678
RIV33	9503661.38	541072.795
RIV34	9503602.663	541035.724
RIV35	9503559.73	540998.564
RIV36	9503480.817	541045.176
RIV37	9503474.78	541136.103
RIV38	9503455.807	541216.742
RIV39	9503425.419	541271.589
BB7	9502939.838	540111.857
RIV40	9502937.345	540187.629
RIV41	9502959.609	540161.144
RIV42	9502971.835	540126.136
RIV43	9503000.314	540134.097
BB12	9504122.472	540271.99
P1	9504167.217	540325.736
RIV5	9504214.289	540278.527
RIV6	9504209.005	540303.989
RIV7	9504210.23	540321.334
RIV8	9504217.135	540357.367
BUMB4	9504338.968	540081.209
RIV1	9504374.423	540090.822
RIV2	9504322.852	540106.799
RIV3	9504308.801	540122.257
RIV4	9504285.099	540209.835
BB13	9504211.337	540436.172
RIV9	9504233.671	540400.168
RIV10	9504227.702	540477.563
BB16	95039228.65	540876.258
RIV17	9504106.176	540722.71
RIV18	9504040.829	540782.58
RIV19	9504044.291	540808.996
RIV20	9504028.948	540837.642
RIV21	9504002.807	540845.65
RIV22	9503993.147	540872.901
RIV23	9503954.095	540871.727
RIV24	9503904.835	540884.257
RIV25	9503872193	540882.514
RIV26	9503859.923	540899.784
RIV27	9503816.004	540908.489
RIV28	9503776.23	540938.852
RIV29	9503740.194	540952.028
RIV30	9503744.872	541012.117
BB14	9504084.709	540602.821
RIV12	9504173.469	540526.187
RIV13	9504131.713	540586.617
RIV14	9504120.577	540626.015
RIV15	9504149.137	540640.5
RIV16	9504179.59	540682.15
BB15	9504108.494	540704.396
RIV31	9503889.354	540869.73
RIV32	9503854.952	540899.628
RIV12	9504122.472	540271.99
RIV13	9504211.337	540436.172
BB14	9504084.709	540602.821
BB15	9504108.494	540704.396
BB16	9503928.651	540876.258
BB17	9503992.248	541075.409
BB18	9504106.801	541522.029
CH1	9504436.164	541291.513
CH7	9503585.836	541991.945

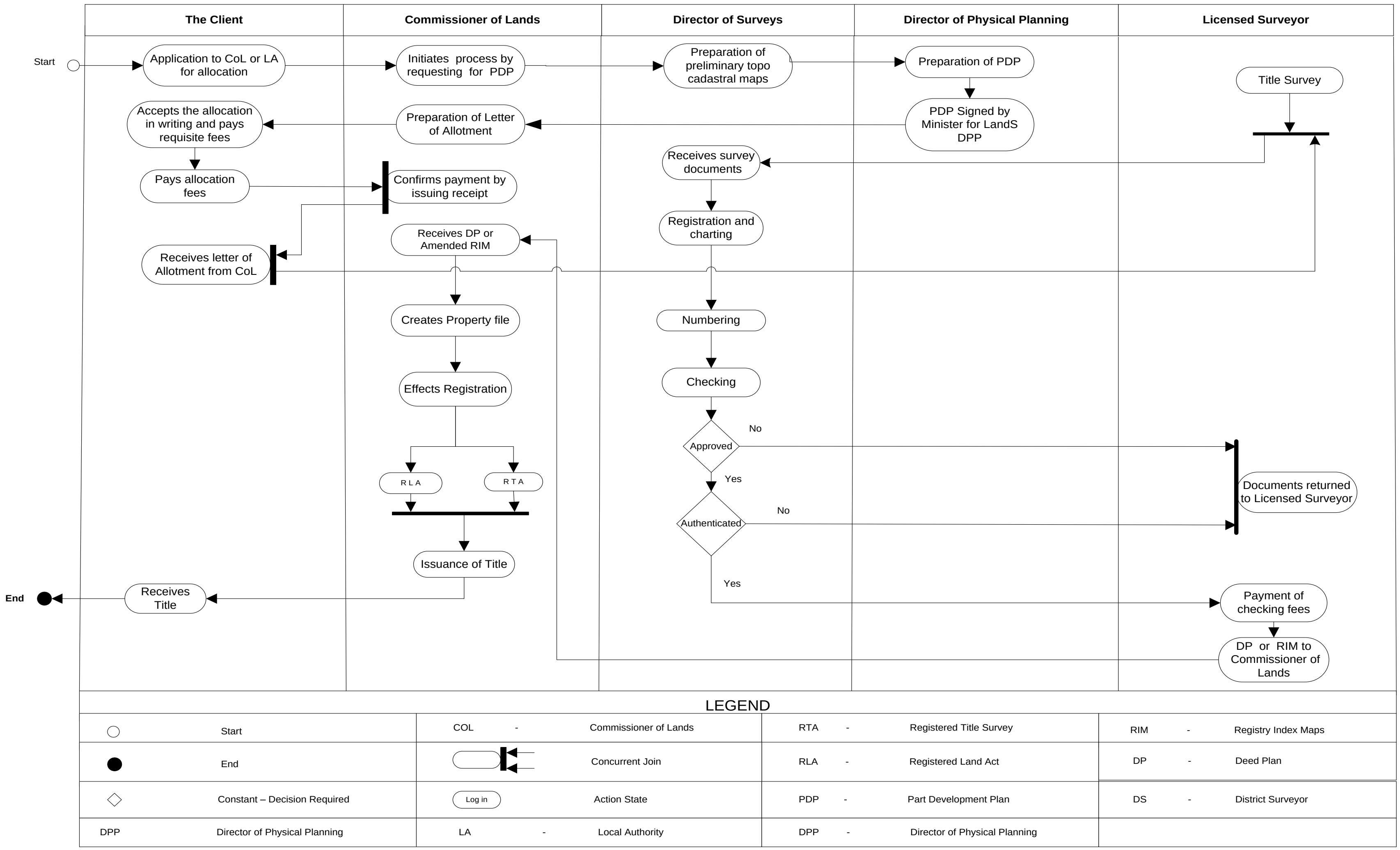
Appendix 14 List of Activity Diagrams



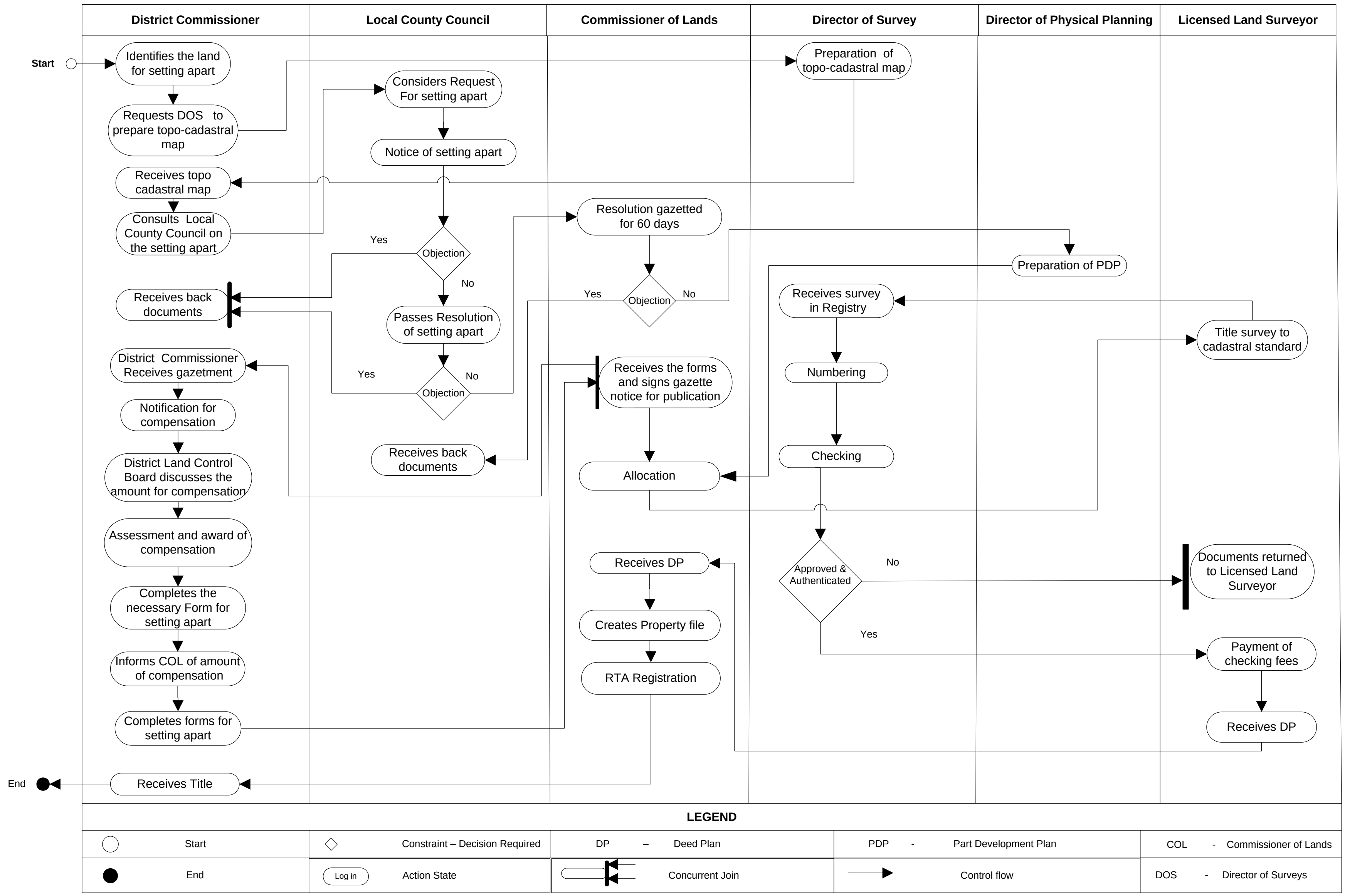
LEGEND

○	Start	◇	Constraint	TS	Technical Section	LAT	Letter of Allotment	DoS -	Director of Surveys	PDP -	Part Development Plan	CoL -	Commissioner of Lands
●	End	→	Control Flow	Log in	ction State	DPP	Director of Physical Planning	LA -	Local Auhtority	HDC -	Head of Development Control	RIM -	Registry Index Map

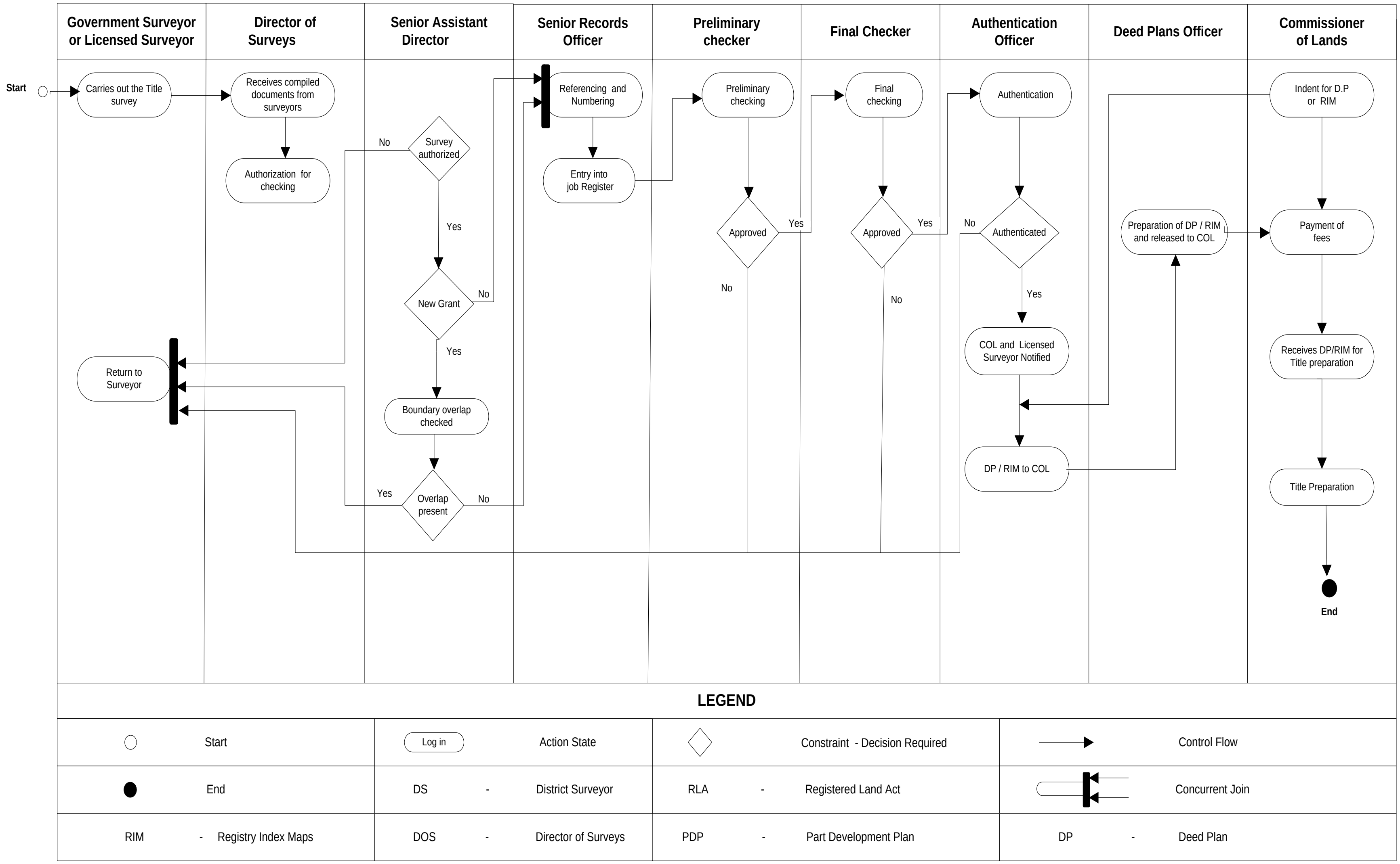
Activity Diagram 2.1 The Process of preparation of Part Development Plan



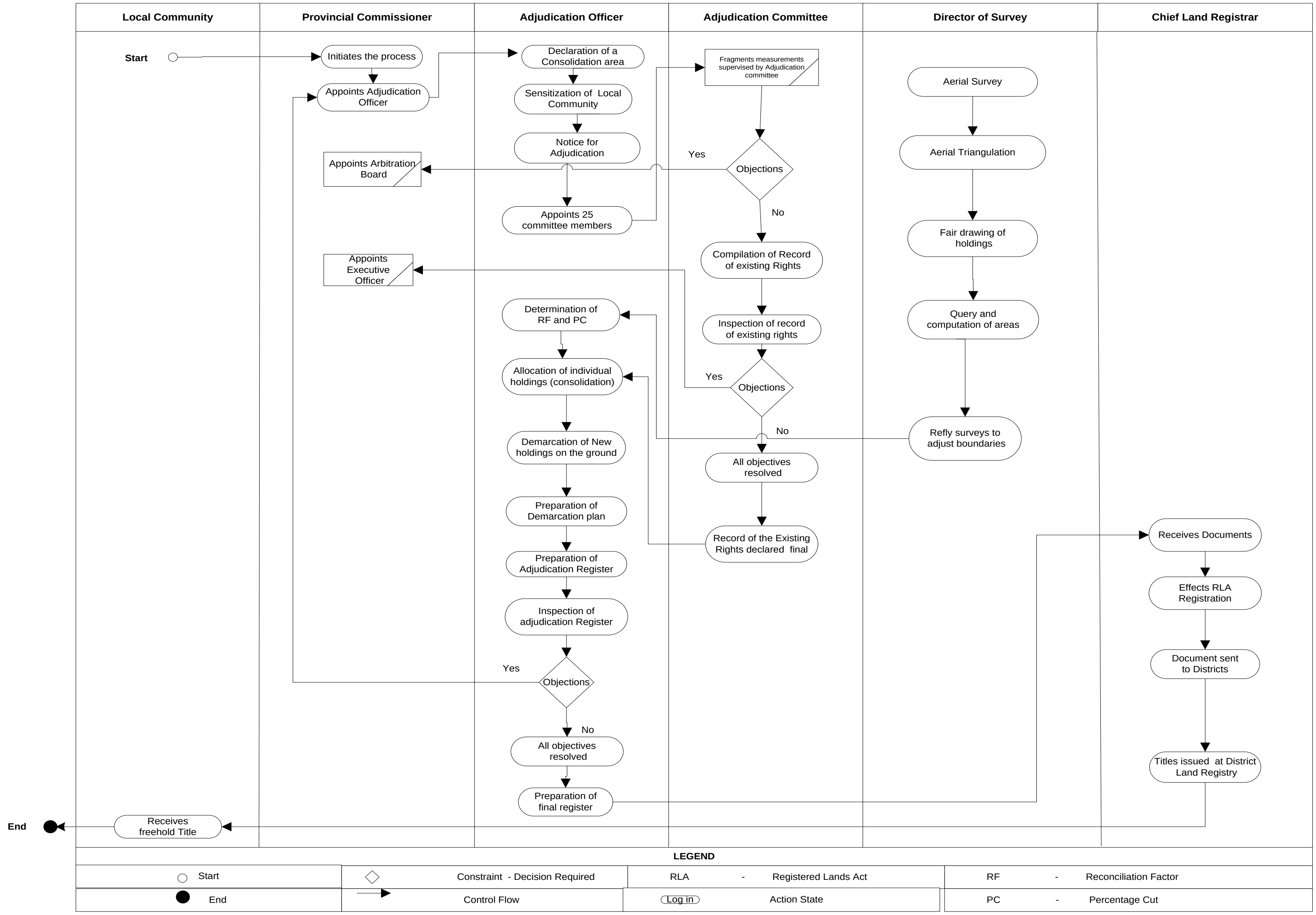
Activity Diagram 2.2 The Process of Allocation of Government New Grants



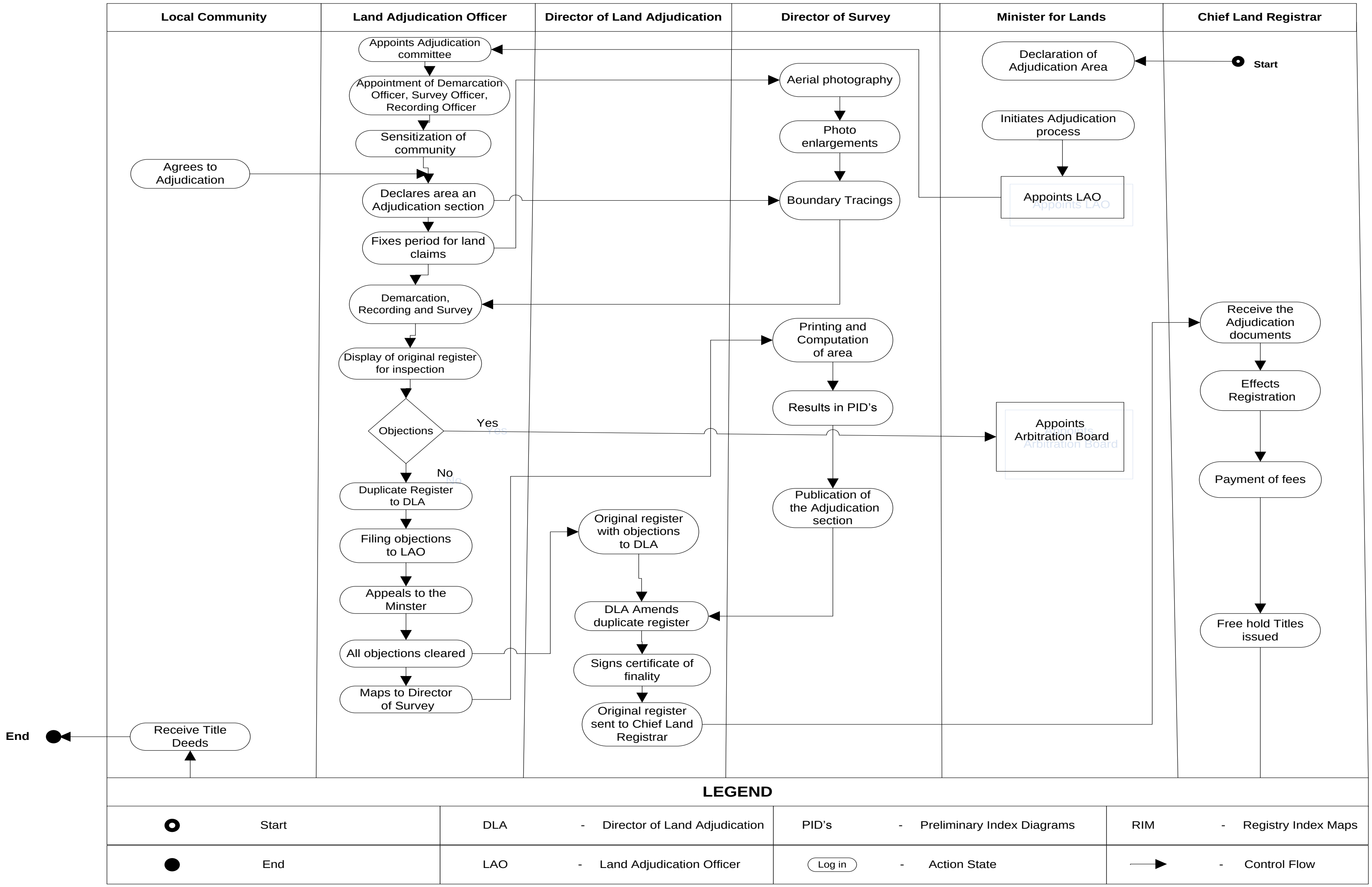
Activity Diagram 2.3 The Process of Setting Apart of Trust Lands



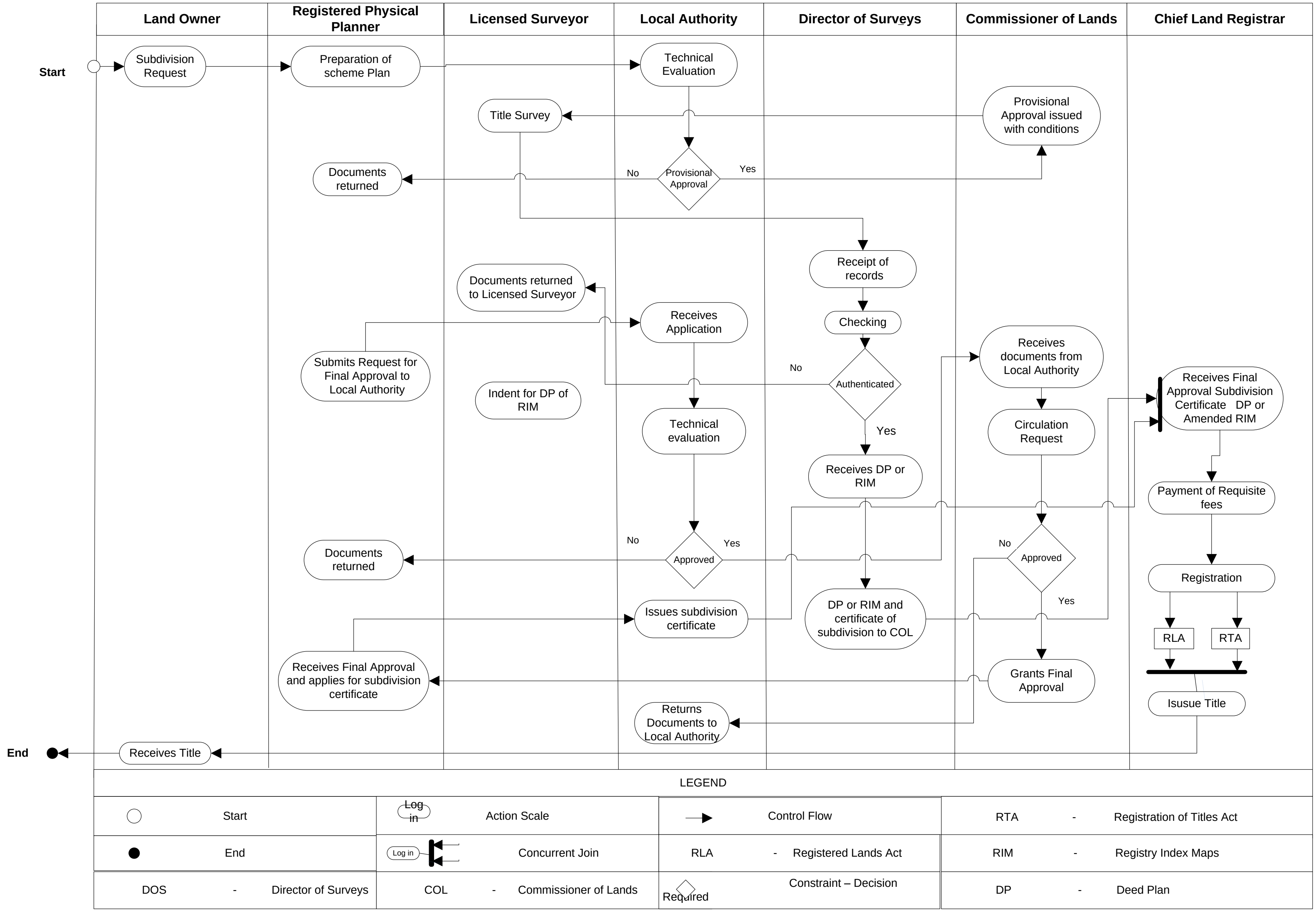
Activity Diagram 2.4 Precise cadastral Surveying Processes



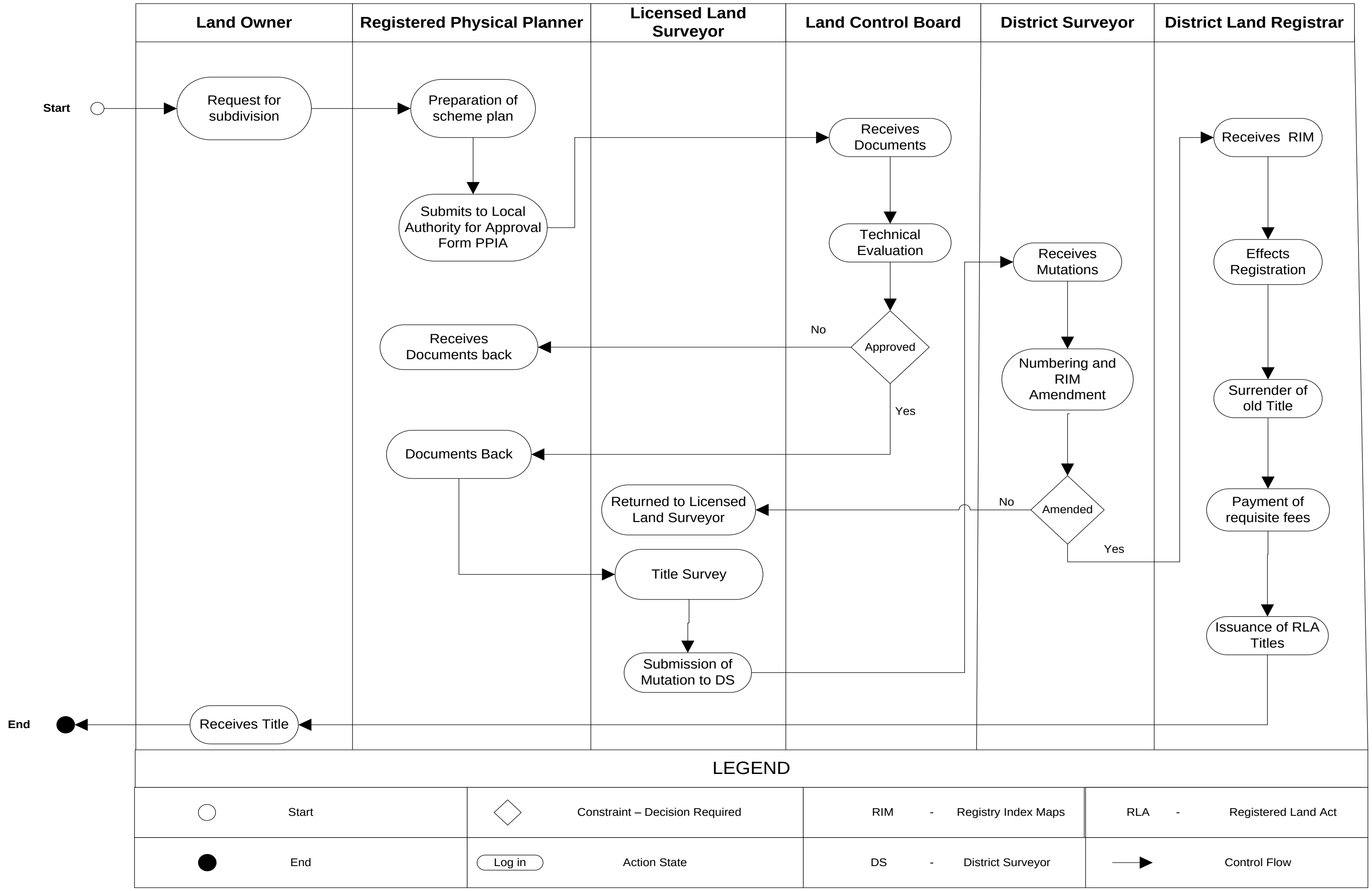
Activity Diagram 2.5 The Land Consolidation Processes



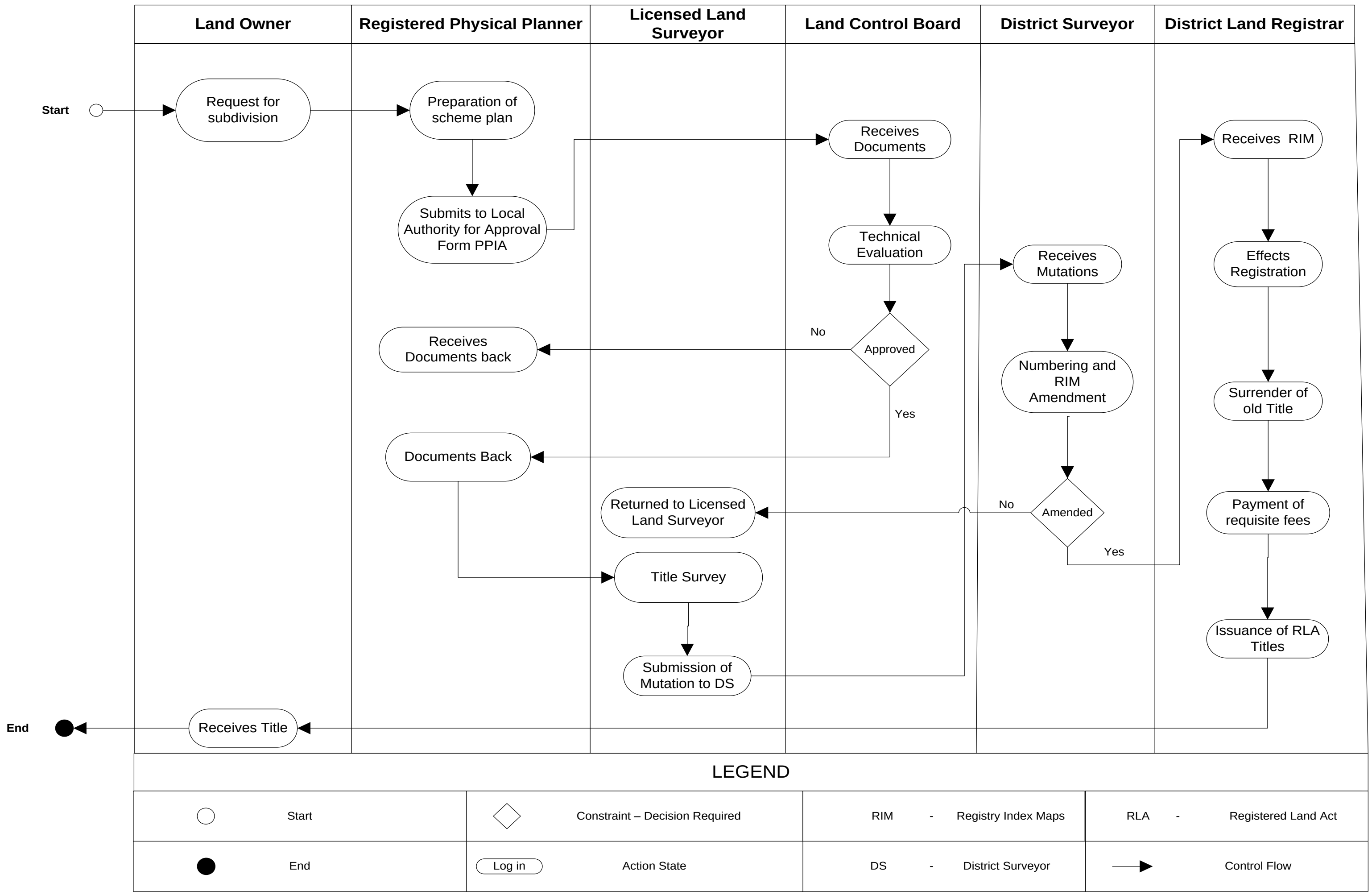
Activity Diagram 2.6 Systematic Land Adjudication Processes



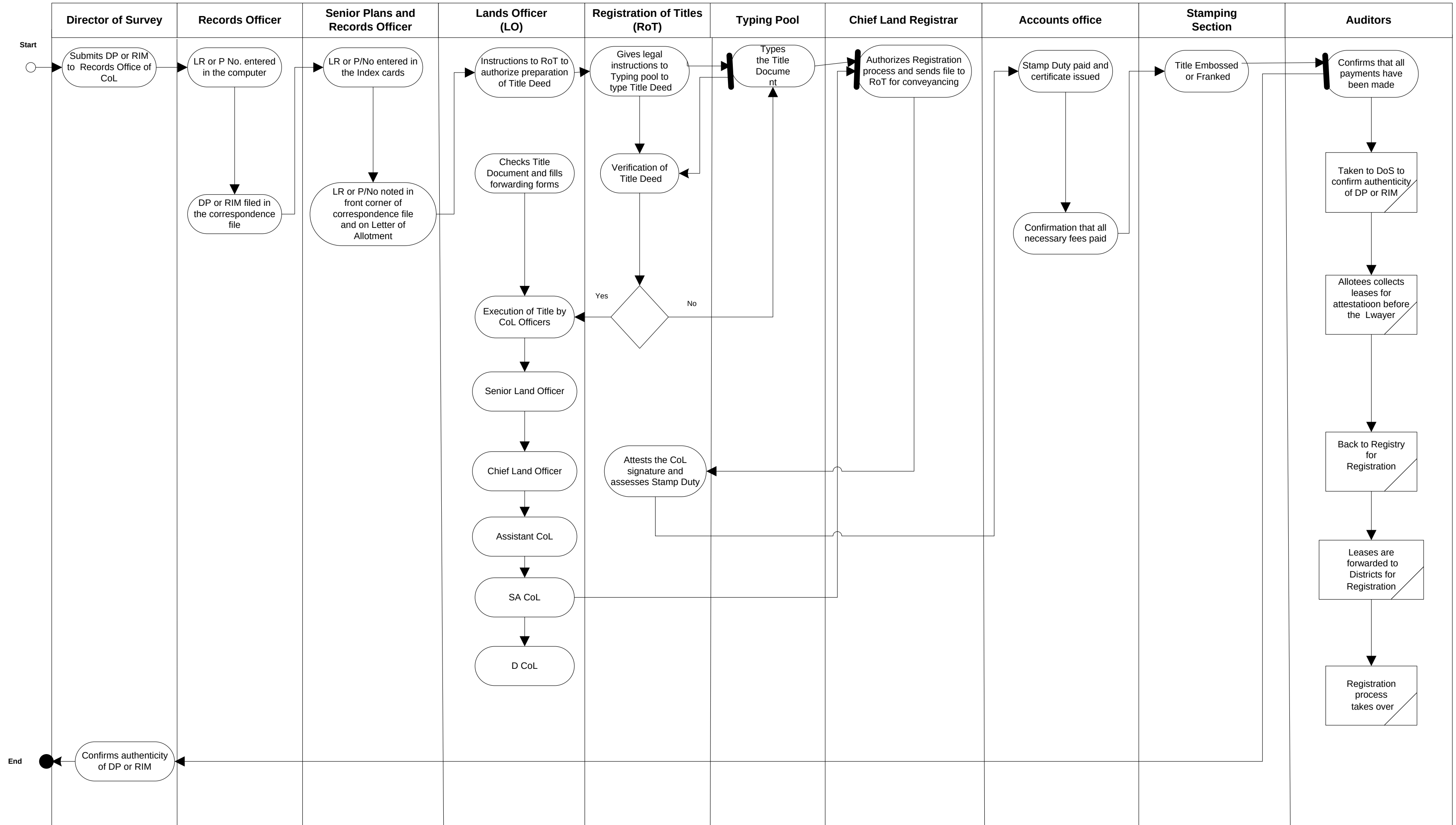
Activity Diagram 2.7 Processes of Subdivision of Urban Plots



Activity Diagram 2.8 The Process of Subdivision of Rural Plots



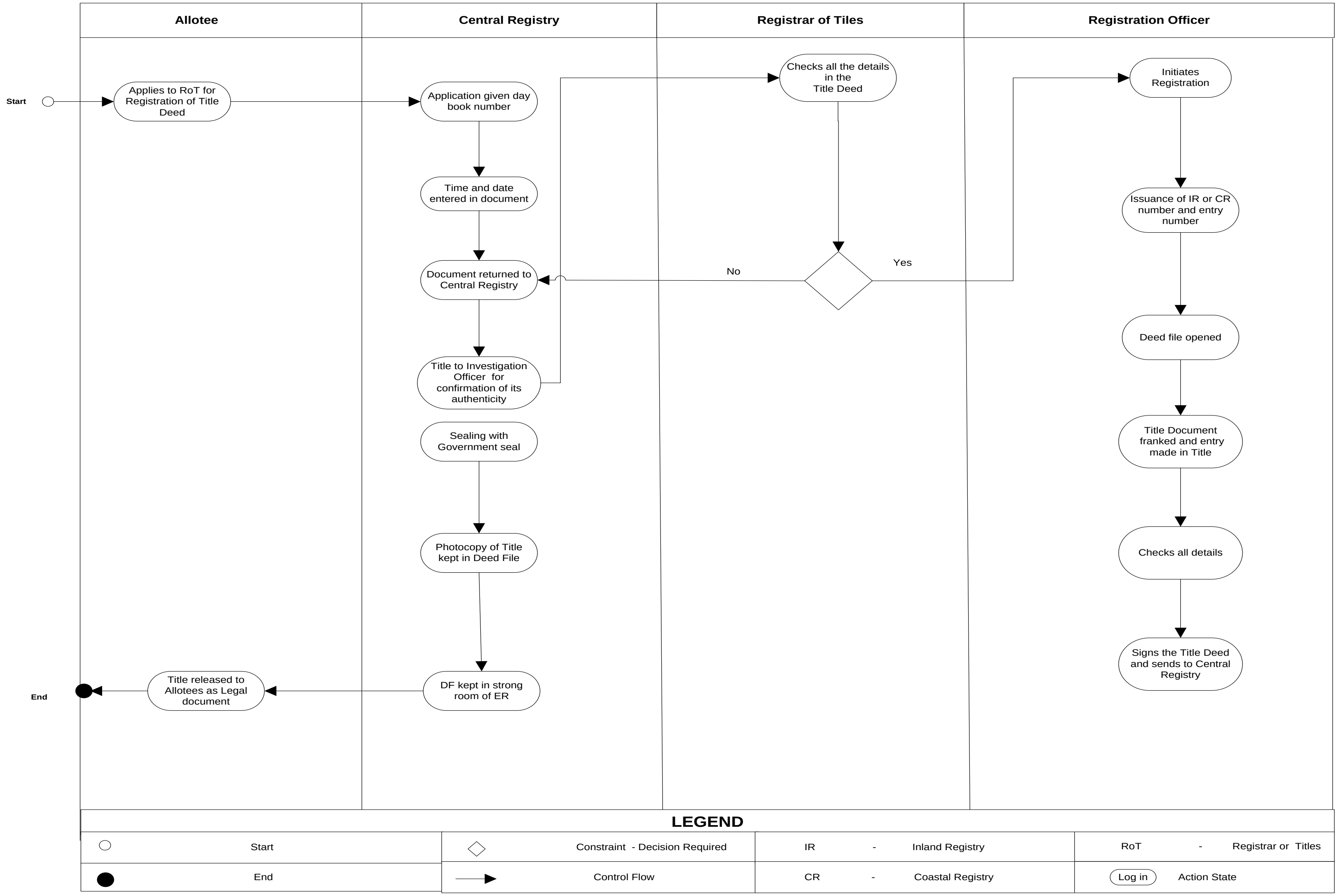
Activity Diagram 2.9 The Processes of Subdivision of Group Ranches



LEGEND

○	Start	◇	Constraint - Decision Required	RLA	-	Registered Lands Act	DoS	-	Director of Surveys	LR	-	Land Reference	CoL	-	Commissioner of Lands
●	End	⟶	Control Flow	Log in		Action State	DP	-	Deed Plan	P/ No.	-	Parcel Number	RIM	-	Registry Index Map

Activity Diagram 2.10 The Conveyancing Processes for Title Registration



Activity Diagram 2.11 Title Registration Processes